Popular Astronomy.

Vol. XXXIII, No. 4 APRIL, 1925 Whole No. 324

ECLIPSE OBSERVATIONS AT VASSAR COLLEGE.

By CAROLINE E. FURNESS.

To be in charge of an observatory situated in the direct line of totality of a solar eclipse entails a great and varied responsibility upon its director. The problems presented are far different from those which astronomers have to deal with who go on eclipse expeditions, and have only some particular astronomical question to handle.

First of all, we must consider the equipment of the observatory and decide how well it is suited to eclipse work of real scientific value. Then there are plans to be made for the students in the department of Astronomy who wish to share in the work and must be trained for special tasks. Next there is the much larger group of faculty, students, and alumnae who have an intelligent interest in the event and need well written and comprehensive directions for observing the various phenomena which can be seen. Finally there is the neighborhood, which may be as extensive as one wishes to make it. For us it included the city, the county and even the school children of the state. For these a different kind of publicity is required. The event is so unique, and of such extraordinary beauty as a spectacle of nature, that a vigorous effort should be made to interest everyone within reach.

It would take a great deal of space to give an account of all that was done at Vassar along these several lines, and much of it would not be interesting to the reader of Popular Astronomy. Hence it seems best to confine the material in this article to the more strictly astronomical work done by the staff of the Observatory, the students in Astronomy and the alumnae and helpers from other places.

In making plans for the use of the twelve-inch telescope I called upon Dr. Miller of Swarthmore for advice, a veteran eclipse observer, who assured me that it ought to take very good photographs of the corona if used with a color screen, and gave suggestions for making a camera attachment. This consisted of a very simple arrangement of one box sliding within another, allowing room for a five by seven plate. The work for it was done by Mr. Lundin of Cambridge, and it was attached to the telescope by the local mechanician. A Wratten ray filter was obtained from the Eastman Research Laboratory, and Cramer Iso-chromatic plates were used.

The camera was in place and ready for use early in January, and the task of focusing it was carried out by Miss Laura Hill and Miss

Alberta Hawes, members of the Astronomy department, who were able to get a very good series of photographs of the moon several nights in succession. Their focus was afterward verified by Dr. MacLaughlin of Swarthmore, who came up a few days in advance to make final adjustments and to take the exposures on the day of the eclipse.

This part of our work was carried out successfully. Eight exposures of the corona were made, in order 2, 5, 9, 20, 30, 9, 5, 2 seconds in length. Dr. MacLaughlin was assisted at the telescope by Mrs. Phoebe Waterman Haas, Vassar A. B., California Ph. D., who came back to help us, and Mr. Wm. Runk of Poughkeepsie. Mrs. Haas counted the exposure times and Mr. Runk handled the plate holders.

We also took a series of partial phases after totality was over, noting the time of exposure for each on the chronograph. These we hope may be of use in combination with those taken at other observatories for determining the position of the moon.

The long exposure negatives of the corona show quite extensive coronal streamers, and the shorter ones give a good deal of detail in the inner corona.

A whole paragraph should be given to a discussion of the weather, which was remarkably fine. It was such a day as we sometimes have in winter in this locality, but on which we can not count in advance. It was clear the night before. A thin cloud came up about five in the morning, and at sunrise there was a dark streak over the sun, while the rest of the sky was clear. By the time it was 7:45 this had broken up into small clouds which faded away leaving a very translucent atmosphere which lasted during the entire morning. The temperature was eleven below zero, which accounted in part for the remarkable clearness. Our local photographer, who takes a great many groups out of doors, was out with his camera and said it was the kind of day a photographer loves for his work, wonderfully clear with strong light everywhere.

The times of contact were observed with the five-inch telescope, but the third one was lost, owing to a slip with the eye-piece, but was taken from the stop watch determinations of the duration of totality. The fourth one was recorded with a watch which was carefully compared with the standard chronometer. Other determinations of the times were made by students with the field glasses but the extreme cold was detrimental to their watches and they are not very exact. The times as obtained with the five-inch are given below.

	Predicted	Observed	
	h m s	h m s	
First contact	8 00 46.2	8 01 29.6	E. S. T.
Second Contact	9 10 57.2	9 11 00.5	
Third Contact	9 12 54.6	9 12 57.1	
Fourth Contact	10 30 07.2	10 29 47.0	

The predictions of the times of contact were made by students in the advanced mathematical course in Astronomy a year ago. Two ap-

proximations were carried out for the second and third but not for the first and fourth. This is one of the reasons for the greater differences in the latter cases between the observed and predicted times.

The errors of the sidereal clock and the chronometer were determined by radio signals direct from Arlington. A special radio set was installed for a period of ten days covering the eclipse, and the signals were recorded on the chronograph together with those from the radio and chronometer. A curve was made which showed the rate of both to be quite regular. Special signals were sent out at 8:40 and 9:40 on the morning of the eclipse. The work of taking care of the clock rates was in the hands of Miss Hill. A special radio operator, a volunteer from the A. A. V. S. O., Mr. Cunningham of North Cohasset, Mass., came two days before the eclipse and remained until after the noon signals of the 24th in order to help out, and relieve Miss Hill for other work.

Observations of the shadow bands formed an important part of our program, and the time seemed especially propitious for them because of the extensive white surface provided by the newly fallen snow of two days before. Observers could be stationed in several different localities offering a variety of contour lines with the possibility of different ground currents. North and south lines were laid out accurately with the altazimuth instrument beforehand in two of the observing places, and those who observed elsewhere used compasses, allowing for the deviation of the needle, which in this locality is 11° west of north.

The reports differ somewhat, but all agreed that the bands lay approximately from northwest to southeast and that their motion was from southwest to northeast. In most places they moved in the same direction before and after the eclipse. In but one place was the direction different. Further investigation of this report will be made as soon as time permits. In some cases they were not seen on the roofs of buildings. There are differences also regarding the width of the bands and their distance apart. It will take a considerable time to collate all the evidence and decide which were the most satisfactory results. The bands seemed to begin about two minutes before totality and last until just after it began. They were seen again a few seconds before the end of totality and lasted nearly two minutes again. In some cases the time was determined with the stop watch. Two observers saw them in a curved shape, as they lay on a rather steep hillside.

It would seem as if the air currents which give rise to them start from close to the ground, and are influenced by the contour of the place. Much interesting material should be gained from the extensive observations which were made at this eclipse.

Some very interesting visual observations of the flash spectrum were made with a simple apparatus which we arranged ourselves. A replica transmission grating was placed over one of the objectives of a pair of field glasses and held in place by a piece of soft chamois in which a

hole was cut large enough to uncover the lines of the grating. The field glasses were then placed in an iron clamp with a heavy base borrowed from the Chemistry department. The stand was then set on a plane table borrowed from the Geology department, making a very satisfactory apparatus. Two of the gratings were borrowed from the Physics department. Three students and one member of the Chemistry department used them, while another chemist used a pair of binoculars fitted with a Wallace direct vision spectroscope with the slit and magnifying glass removed.

All who made this observation practised beforehand on the spectrum of helium in a vacuum tube. The narrow bore of the capillary tube acted in place of a slit. The coronium line should come a little to the red side of the green helium lines. As a further guide to its identification they planned to use the D3 line and the Hβ line.

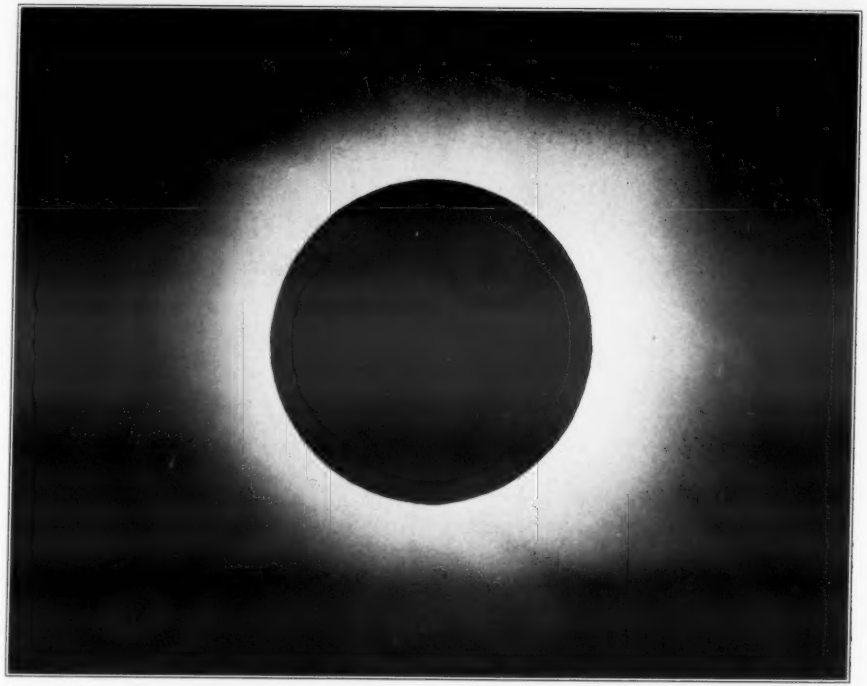
On the day of the eclipse they all saw the dark curved lines forming in the solar spectrum as the solar crescent grew narrower. The spectrum grew narrower and narrower until it disappeared and the flash was visible for an instant only. The D3 line became strongly visible, but not all saw the green line of coronium. Those who did see it said it came slowly and late and that it was curved outward toward the right, implying that it came from the right edge of the sun. The corona seemed to the eye to be brighter here, which may account for the appearance of the line. A faint continuous spectrum was visible during totality.

Observations of this kind seem to me to be very useful when taken in connection with photographs of the corona. They may enable us to decide how much of the light of the corona comes from the gas coronium and what part of it must originate in some other way. A small telescope could be used in this way with a grating or objective prism, such as was used so successfully in the Indian eclipse or later by the English observers in that of 1900.

Three small telescopes were used by students in drawing the corona. They practiced beforehand by drawing from illustrations in books, first for accuracy and later for speed, while some fellow student held the book and timed them. The results were quite gratifying. One drawing especially, showed a number of prominences with excellent detail. This drawing later I shall have an opportunity of comparing with the photographs of Dr. Miller at Swarthmore. If there is good agreement, or if our drawing shows prominences which the photographs do not, and which coincide with arches in the corona, it would prove that eye observations are still useful in eclipse work, an opinion which I hold rather firmly at present.

Counting the seconds during totality was done with the aid of the Western Electric Company, through whose courtesy a set of loud speakers was installed in important parts of the ground. It was the first time, I believe, that they had been used out of doors in the snow.

PLATE XIII.



PHOTOGRAPH OF THE SOLAR CORONA, JANUARY 24, 1925
taken at Vassar College Observatory.

PLATE XIV.

N

E W

Photograph of Inner Corona taken at Vassar College Observatory.

Students at Vassar College Observatory observing the Flash Spectrum with field glasses and gratings.

The microphone was placed in the office of the Observatory and the seconds were called into it by Mrs. Harriet Parsons Hall, Vassar A. B., Chicago, Ph. D., who came back to help us. She observed the time of second contact with the field glasses, and counted with the help of a stop watch, every fifth second up to one hundred, then every second. Two of the loud speakers were in small buildings adjoining the Observatory, one was in the dome, two in a field close by, and two near the Alumnae House about a quarter of a mile distant. The sounds were heard quite perfectly.

Something should also be said about the contribution made by the American Telephone and Telegraph Company to the eclipse campaign. They established special telephone and telegraph circuits connecting several observatories together, so that the times of second contact were all recorded on their clock in the laboratories of the Western Electric Company in New York. Those so linked together were Harvard, represented by Dr. Shapley at Buffalo, Cornell, Vassar, Yale, Wesleyan, and the temporary station of the *Scientific American* at Easthampton, N. Y. This has probably been fully described in other reports, and nothing further need be said here.

The funds for carrying out our plans for the eclipse work were provided by the Whitney fund for astronomical research, the income of a bequest given by Professor Mary W. Whitney to the College. This was not the first effort made by Vassar astronomers to observe an eclipse. In 1869 Professor Maria Mitchell took a party of eight graduates of the College to Burlington, Iowa, for the eclipse of Aug. 7, among whom was Mary Whitney. In 1900 Prof. Whitney and myself went to Wadesboro, but this time the whole College formed the "Eclipse Party."

THE ECLIPSE OF JANUARY 24, 1925, AT THE FUERTES OBSERVATORY.

By C. M. PENDLETON and S. L. BOOTHROYD.

Of the contemplated program for this Observatory, the following were carried out with some success: Times of first, second and third contact were determined; clouds prevented obtaining the time of fourth contact. The times of contact scaled from the map accompanying the report of the U. S. Naval Observatory on the eclipse or computed from the Besselian elements, together with the observed times, are given in the accompanying table:

	From Map	Computed	Observed
	h m s	h m s	h m s
First Contact	12 59 44		13 00 32.1
Second Contact		14 08 39.9	14 08 45.1
Third Contact		14 10 29.6	14 10 37.0
Fourth Contact	15 26 14		Cloudy

The chronometer correction was obtained from records of the chronometer times of reception of the wireless noon signals from Arlington on Jan. 20, 21, 22, 24, and 26, together with comparison with the special signals sent from Arlington at 8:40 and 9:40 on the morning of the eclipse. Static on the 23rd was so bad that no reliable record was possible. Bad weather and professional duties prevented us from getting enough of our own observations for times to be of any use. It should be noted in passing that the chronometer correction obtained from the noon signals on the dates mentioned agreed with said correction obtained from the special signals within a tenth of a second.

There is no doubt that the time of first contact is a number of seconds late. Trees near the observatory prevented getting an unobstructed view of the sun with the telescope at that time and the contact was not seen until it was very evident, as the many little branches seen against the sun interfered with proper observation.

The time of second contact was well observed and, as it was recorded at New Haven by the operator here who was sent by the American Telephone and Telegraph Co., as well as by our man at the chronograph, we have a good check on this record. Our man recorded it on the chronograph here 0.2 seconds later than the time recorded on the chronograph at New Haven. As our man at the key was not experienced at such work, it is not strange that there is a slight difference and I think there is no doubt that his record of the time of third contact was late by one or two seconds. The first contact was observed by Prof. J. E. Perry, using a four-inch portable equatorial. The second contact was observed by S. L. Boothroyd, using a direct vision spectroscope, and checked by J. E. Perry, using the 4-inch portable telescope. The third contact was observed by S. L. Boothroyd, using the direct vision spectroscope. It had originally been planned to have the same man use the chronograph key, who observed the second and third contact, but almost at the last minute before totality it was necessary to move the chronograph and key in where is was warm, for the extreme cold made it impossible to use it outside. This made it necessary to have one man at the key who recorded times as received orally from the man who observed the contacts. Mr. Brittain, the man operating the telegraph instrument, of course received the time of second contact orally from S. L. Boothroyd and thereupon made the dash which made the record on the chronograph at New Haven.

The photographs of the inner corona with the 12-inch equatorial were not exposed, due to the failure of the men in the dome to hear the signal for the beginning of totality. As our concave grating spectrograph for securing the flash spectrum was carried on the mounting of the 12-inch, the program for securing the flash also failed of accomplishment.

The outer corona was photographed with a Ross lens which was loaned by the Lowell Observatory. The focal length of the lens is

approximately 8 inches and the focal ratio 1 : 2.5. The accompanying photographs are enlargements from negatives secured with this camera. We also secured a spectrogram of the corona with a two prism slitless spectrograph loaned by the Lowell Observatory. This spectrogram is not very good, but yet it contains a great amount of information which will be made available as rapidly as possible.

The slitless spectrograph and the camera with the Ross lens were both mounted on the polar axis of the 4-inch equatorial, which was erected on a concrete pier under a temporary shelter to the southwest of the dome. Mr. E. C. Slipher of the Lowell Observatory was in charge of the instruments under the shelter and our success with this part of the program is due in large measure to his skill.

The shadow bands were very prominent and were well observed by Mr. E. C. Slipher, Mr. Olds and several others, there being remarkable agreement as to direction of the bands and their direction of motion. Their distance apart was variously estimated at from 10 to 17 inches. This was very hard to estimate on account of their rapid motion, as was also their width which Mr. E. C. Slipher estimated as 1½ inches. The direction was northeasterly and southwesterly, making an angle of about 30° with the meridian and the motion was in the direction N 30° E. It should be noted that the wind was blowing from a southeasterly direction approximately at right angles to the shadow bands. An observer to the south of town reported that she thought there were two sets of shadow bands, one prominent set as described having a width of about 3 inches, and a fainter set 2 inches wide superposed upon these and moving in the same northeasterly direction. It should be noted that the clouds, which covered the sun soon after first contact and which drifted away from the sun about 14 minutes before totality, were moving in a direction almost exactly opposite to the surface wind. Observations reported by parties at various places in or near the path of totality all agree in giving the direction of the bands approximately perpendicular to the direction of the surface wind. The motion of the bands was likened by many to a serpent racing very swiftly.

The evening before the eclipse was cold and cloudy, with signs of clearing at 10 P. M. and quite a little clear sky around the zenith about midnight. At 4 A. M. on the morning of the eclipse it was —10° F, the coldest of the winter up to that time. The temperature had risen to +6° F just before totality.

It will interest readers of POPULAR ASTRONOMY to know that Prof. W. C. Baker, Prof. Louis Fuertes and an art student, Miss Dvorak, made color sketches of the eclipse and are preparing oil paintings, using the photographs to give them the true form. Professor Baker has already completed his painting.

As the writers put in all their spare time for six weeks before the eclipse in making the spectrograph for the concave grating, in getting

the mounting erected under the temporary shelter, in adjusting the instruments and other necessary work, we naturally were much disappointed that a slip at the critical moment should have caused the failure of part of our program. The focus for the 12-inch equatorial was very fine and, if even one exposure had been made, we should undoubtedly have had a good photograph of the inner corona.

We wish here to thank all who assisted on the day of the eclipse and before, and especially do we appreciate the response of Director Barnes of the School of Civil Engineering and Dean Kimball of the College of Engineering for their hearty coöperation in providing the funds necessary for the preparations. We especially thank the Lowell Observatory for the equipment which they loaned, and Mr. E. C. Slipher for his invaluable assistance in mounting the slitless spectrograph for photographing the coronal spectrum, as well as for his efficient assistance on the day of the eclipse.

VISUAL OBSERVATIONS AT THE TOTAL SOLAR ECLIPSE OF JANUARY 24, 1925.

By SEBASTIAN ALBRECHT.

In view of the fact that it has been the nearly universal experience of astronomers to be preoccupied at times of total eclipses of the sun with the manipulation of telescopes, cameras and spectroscopes, it may be worth while to record visual observations made at the recent eclipse with no instrumental equipment except a pair of binoculars, which were used only for a better view of the prominences. The eclipse was observed from the Cottam Dahlia Farm near Wappinger Falls, about five miles south of Poughkeepsie, New York, and about three miles north of the central line of the shadow path. This farm, selected by Miss Furness, is situated on a long narrow ridge approximately parallel to the Hudson river, which is about a mile west and two hundred feet or more lower than the top of the ridge. This site was ideal for eclipse purposes, affording a clear view to the west, down to and across the Hudson river and to the Catskill Mountains about six miles beyond, and a similar open view to the east. The chief aim was merely to see the eclipse and to obtain as good an impression as possible of the phenomena during totality and immediately preceding and following it. Most of the sky was free from clouds, and for many degrees around the sun the sky seemed perfectly clear. The temperature was about ten degrees below zero Fahrenheit, and scarcely a trace of wind was perceptible.

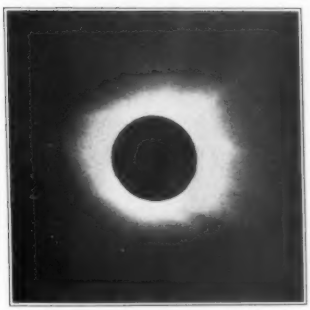
Shadow bands were observed on the snow-covered ground which slopes down very slightly toward the east. The bands were first noticed at about two minutes before totality, though I have no doubt that they were present earlier. In fact after third contact they were seen for

PLATE XV.

Photograph with hand camera by
E. L. Wolven, photographer,
of Poughkeepsie, N. Y.

N

E



W

Photograph of the Solar Corona taken at the Fuertes Observatory, Ithaca, N. Y., using the Ross Lens of the Lowell Observatory. Exposure one second.

This picture shows the coronal streamers. Note the long spike-like streamer extending from the N. W. quadrant of the sun. This was traced by the eye to a distance estimated as two solar diameters from the limb of the moon.

about three minutes. As nearly as one could estimate, the bands extended lengthwise in the direction toward the sun, i. e., parallel to the intersection of the ground and the vertical plane passing through the sun. They were usually not continuous for any considerable lengths, so that it was difficult to run the eye along any one band for more than ten or twelve feet. Often they were of shorter lengths, at times as short as three or four feet. The darker central part of the shadow band averaged perhaps a quarter of an inch in width, and then shaded off unequally and non-uniformly toward the two sides. The light spaces between bands were several times as wide as the bands. In any particular set the widths of the bands and their distances apart appeared to be more or less uniform. The shadow bands were quite wavy and colorless.

The varying length and difficulty of following individual bands are intimately connected with their relatively temporary nature. They would appear, tremble for one, two or three seconds (or, as my daughter remarked "shiver in the cold") and then run at right angles to their length. At times they would fade out and be immediately replaced by new ones. Even though there was a considerable amount of regularity in the widths and separations of the bands, there were occasional and sudden changes. The usual interval between bands was perhaps eight or ten inches. This would at times change suddenly to four or five inches, and immediately preceding their final disappearance after totality it widened out to more than eighteen inches. At one time the small group of people near me watched two distinct and parallel sets of bands adjacent to each other in the direction of their length. In the set at our feet the interval between bands was about eight inches, while in the set about five feet farther forward (toward the sun) the interval was only about five inches. They persisted as distinct sets for perhaps ten seconds. They did not overlap, but their adjacent ends were disjointed along a boundary line. The motion at right angles to their length was at first very slight, and by the time they had attained a speed of about two or three miles an hour they had disappeared and were replaced by what appeared to be a single set. Unfortunately I failed to note the widths and other details in the succeeding set.

One additional observation in regard to the shadow bands remains to be noted, namely: Before totality the bands moved toward the right (as one faced the sun), i. e., in a southwesterly direction, while after totality they moved toward the left, i. e., in a northeasterly direction. The average speed of motion was about that of an ordinary walk, i. e., about three miles an hour. This change in the direction of motion may or may not have some connection with the fact that the light from the visible crescent crossed over to our place of observation from the left of the shadow cone on its preceding side, and from the right on its following side. If this is the controlling factor then other observers close to the central line should have noted the same change in the direc-

tion of motion of the bands which we observed. It seems plausible that the shadow cone would be attended by a temperature gradient which would be roughly radial and would therefore tend to superimpose upon the existing air currents a more or less radial component. On the other hand the local topography of the land may exert a marked influence in controlling or modifying these currents. I had been prepared for a possible change in the direction of motion of the bands before and after totality by an account of the clipse of 1806 written by President Nott of Union College. His description states that the bands all ran toward the horizon, and after totality all ran toward him. His orientation was not given nor was it certain but what he might have meant that the bands were concentric with himself, and ran away from and later toward himself in all directions. In order to make sure of obtaining a definite observation on this point, I asked the small group of people near me at the time the bands were on the ground, both before and after totality, to notice the direction of motion. The bands were distinctly not concentric with the observer, nor were their relative positions on the snow influenced by any motion of the observer.

The shadow bands were not quite as sharp and clear cut nor were they as steady as I had expected. They were somewhat elusive, due to considerable trembling and at times hesitation and confusion. I believe it not at all unlikely that during a good share of the time two sets of bands of wider intervals were present simultaneously, one superimposed upon the other, and probably originating in different levels of the atmosphere. It seems to me likely that the shadow bands which an observer sees have their origin in the atmospheric waves or currents in his vicinity, and usually within elevations above him measured in hundreds rather than in thousands of feet. The shadow bands on the ground were of such a nature that they could hardly have been seen or photographed from an elevation of a thousand feet or more. To be observed from an airship they must be caught on surfaces close to the observer, and the relative speeds of the airship and shadow bands must not be great.

The duration of the shadow bands was much longer than expected. However, at two minutes before and at two minutes after totality the phase of the eclipse was approximately the same as the maximum at Albany, which is 25 miles north of the northern limit of totality. There is no doubt about the visibility of the shadow bands in Albany, and according to the reasonably consistent evidence of numerous people, they lasted fully five minutes and their motion was toward the northeast.

The moon's shadow was quite apparent in the air above the Catskill Mountains but, although we were favorably situated, we did not see it coming down the slope toward the river. We missed it in part on account of the distraction of other phenomena and in part because the shadow was much lighter and probably much less sharp than we ex-

pected it to be. Also near this time the sun's light seemed to diminish in jerks, giving the impression—whether real or not—of maxima and minima. Two or three of these followed in fairly quick succession. To definitely connect these with possible diffraction bands preceding the moon's shadow would require accurate time records, which were not made. Here and at numerous other instances a dictaphone would have proved invaluable.

The corona was distinctly of the so-called sun-spot minimum type. One streamer could readily be followed to a distance of nearly two diameters of the moon's disk. In spite of the well-known limitations of the photographic plate in respect to the range of intensities reproduced, a positive on glass made from a good long-exposure photograph taken with a 40-foot telescope is a much more nearly true representation of the general effect upon the unaided eye, including the color of the corona and the blackness of the disk of the moon, than we are accustomed to believe. The principal difference is that the eye sees in addition some of the detail shown on plates with shorter exposure, and perhaps misses a little of the very faint outermost portions of the long streamers recorded on the plates. To me the color of the corona appeared white with little or no appreciable trace of yellow. One of the greatest changes that occurs within a second or so after the reappearance of the first trace of the sun is the change in the color of the moon's disk from a wet slate black to the slightly milky or grayish blue color of the sky near by. The change is so striking that this, together with the disappearance of the outer corona, probably is the real cause for the statements found in so many reports of eclipse observations to the effect that the corona disappeared immediately upon the reappearance of the sun.

Only one prominence was observed somewhat carefully. Its color was not a deep red as I had expected, but it was more of a pink or what many observers recorded as a light rose color. As the prominence was more and more uncovered by the moon it gradually changed to more of a golden color and became whiter.

I have just read a considerable amount of eclipse literature, i. e., reports of eclipse observations by Struve, Airy, Gould, Julius Schmidt, Burnham, Keeler, Perrine, and many others, in order to obtain an idea as to the extent to which the last eclipse was normal or unusual. With the recent experience freshly in mind, one arrives at the inevitable conclusion that the last eclipse was essentially normal in many respects. Although the snow on the ground undoubtedly added to the general illumination by reflecting and diffusing back into the air a considerable percentage of the coronal light, nevertheless we are apt to overestimate its effect. In the reports on former eclipses when there was no snow on the ground, even with durations of totality of from three to six minutes, there is a fair degree of unanimity that the eclipse was "much brighter than was expected." Usually the observers at the

telescopes record that they could and did quite comfortably make their records and drawings without the aid of artificial illumination. Gillis calls especial attention to this fact because he happened to notice another observer near him using a lamp for similar purposes. Often when one observer records a "dark eclipse," one will find a report on the same eclipse by another observer stating that he was able comfortably to make his records and drawings without the aid of artificial illumination. The condition of an observer's eyes at that time plays a very important role in this connection. The eclipse of January 3, 1908, which to most observers was a dark eclipse, seemed to me quite bright. However, my eyes were quite sensitive because I had been in the 40-foot tower immediately before and during the early part of totality and, when I came out while the long exposure was in progress, I could see people and objects at some distance quite clearly and the sky seemed fairly bright. Although the 1925 eclipse will go down in history as a "light" eclipse, my son saw eight stars, while at numerous "dark eclipses" only from five to ten stars were seen.

Dudley Observatory, February 16, 1925.

SHADOW BANDS AND SEARCHLIGHTS.

By PRESTON R. BASSETT.*

The elusiveness and erratic behaviour of the eclipse shadow bands have caused a certain mystery to cling to them even up to the recent eclipse. Although many contradictory and fantastic explanations have been put forward, it is now generally agreed among astronomers and physicists that the bands are of atmospheric origin. S. A. Mitchell in the 1924 edition of "Eclipses of the Sun" devotes a section to shadow bands, in which he states that "these shadow bands appear to have an importance which is not astronomical but entirely meteorological." Humphreys[1] and Hastings[2] have also independently arrived at similar conclusions which now appear to be well confirmed.

It has been my privilege during ten years of experimenting with large high intensity searchlights to have had opportunities for very unusual observations of the penetration of light through the atmosphere.

It is necessary, in making photometric measurements of powerful searchlight beams, to be situated at a considerable distance from the source of light. Measurements are seldom made nearer than ½ mile and on many occasions from two to ten miles have intervened. From

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[1] Physics of the Air, W. J. Humphreys.

[2] *Popular Astronomy*, **32**, p. 411, 1924.

such distances the searchlight appears practically as a point source of light. A 60″ searchlight, for instance, subtends an angle of only 2 minutes of arc at two miles. With a beam candlepower of 800,000,000, however, an illumniation of over five foot-candles is obtained at this distance in clear weather and when this falls on some vertical screen, such as the side of a house, we obtain most remarkable point source projection. Shadows of all objects are intense and sharp. Twigs of trees 300 feet from the screen will cast such sharp shadows that a series of beautiful diffraction bands is visible around their edges.

But when no objects intervene and the screen is exposed to the clear distant source it is very frequently possible to see wavy dark bands pass across the illuminated field. The bands are very distinct, sometimes sharp and dark and at other times quite thin and light. When there is no wind the bands pass vertically upwards at a rate of about one or two feet per second. When there is a wind the bands dance or frisk quite rapidly and irregularly in the direction of the wind but always with a noticeable upward component. They generally have their long dimension at right angles to their apparent motion. The bands are quite irregular as to spacing and are noticeably convex in the direction of travel.

When these bands were first noticed it was on a two mile range where both searchlight and observer were about 200 feet above the intervening terrain, which was a well built up residential section. It was thought at first that smoke might be causing the effect. It was not, however, as it was later determined that even a small quantity of passing smoke was easily detected with the photometer, whereas the shadow bands could not be detected with the photometer. Subsequent tests on locations without intervening houses and in some cases across stretches of water have usually shown the presence of the same phenomena, but not always so conspicuously.

The three requisites for observation of these atmospheric convection shadows are (1) sufficient distance from the searchlight so that it subtends only a few minutes of angle, (2) sufficient illumination at this distance for the eye to easily discern small contrasts on the field—over one foot-candle—(3) the turbulent mixing of air masses of different temperatures.

When the attempt is made to transfer these prerequisites into natural circumstances it is found that no usual conditions fulfill the requirements. Venus and the new moon both subtend angles small enough to cast shadow bands but they lack sufficient intensity to cast any shadows at all. The sun would cast shadow bands most of the time except for the fact that it subtends too great an angle (½°), which is more than enough to completely blur out the frail and slender atmospheric shadows. Nature apparently has only one "set up" which fills all of the requirements and that is the sun's crescent just before and after a total eclipse. So this most unusual sight is furnished as an added at-

traction only at those rare intervals where there is already too much to see in the short allotted time.

It was with these ideas and searchlight observations in mind that I chose a position near the center of the eclipse path at Stratford, Connecticut, in the middle of a field of clean snow, to see whether the shadow bands would be recognizable as the familiar convection shadows.

The shadow bands appeared on schedule about three minutes before totality and again for a similar length of time after totality. They were sufficiently distinct to obtain good estimates of speed and thickness. Although giving a general appearance of regularity, due probably to their motion, they actually varied from 5 inches to 12 inches in spacing and from 1 inch to 3 inches in thickness. The direction of travel was from southwest to northeast and the velocity about 3 miles per hour as determined by pacing with them, which checks well with 4 ft. per second as determined by timing between two marks on the snow. The bands were wavy and not over two or three feet in length, although here again they gave an illusion of being more or less continuous stripes. The bands had the same direction, velocity and appearance after the eclipse that they had before it. There was a gentle breeze blowing throughout in the same direction as the bands were moving. About ten minutes after totality, as we were leaving our location, an unusual opportunity presented itself for corroborating several important items. In passing a house we were surprised in seeing the shadow bands apparently reappear on the snow. It was evident from the shadows that the source of these bands was hot air from the house chimney. No visible smoke could be seen issuing from the chimney and yet the bands on the snow persisted for twenty to thirty feet from the point of origin.

These shadows, after they had drifted more than ten feet from the starting point, became strikingly similar to the bands which had been witnessed ten minutes before. Measurement of their direction and velocity checked as closely as possible with the real shadow bands. The greater heat of this air accounts for duration of these bands after the natural bands had disappeared. Since this chimney turbulence was traveling in the direction and at the rate of the surface wind it appears indisputable that the true shadow bands, in this region at least, were also produced in the lowest air stratum. A further feature that adds weight to this point of view is that the wind was a local wind, blowing in a direction different from the prevailing wind as recorded in New York and New Haven, and hence this breeze was probably of no great depth. There was considerable cloudiness during the early morning, some cirro-stratus and a variety of rapidly dissolving alto-cumulus and alto-stratus, probably of the winter-night radiation type. These high clouds all had a rapid movement from northwest to southeast at a velocity of at least 50 miles per hour. These levels are therefore precluded from consideration as possible shadow sources on ac-

count of the great differences both in direction and velocity from the observed bands.

Considering, therefore, that the shadows were produced in this case from within the low local wind, the remaining question is what form of disturbance makes it possible to cast shadows from the air. It has been suggested that ripples or irregularities may form in the air, by air currents passing over each other, and that these ripples refracting the light make the shadow patterns which we see. The wavy light pattern that a street lamp throws on the wall through a pane of window glass, or the pattern of water ripples cast by the sun on a shallow sandy bottom, are good examples of irregular refraction patterns caused by ripples and can be studied with considerable profit.

The patterns produced by these means are always a series of thin bright bands against a less bright background. The pattern is the reverse of the shadow band pattern which consists of dark bands against a lighter ground. This difference is significant. The bands produced by the searchlight give the clue to the difference. They are projected horizontally, which makes the cause more recognizable than the unnatural slanting or vertical projection from the eclipse. My searchlight observations have convinced me that the bands are caused only by that portion of the edge of an air eddy, or whorl, to which the rays of the light source are tangent. This is the point of maximum refraction and the only point capable of causing sufficient refraction to make a noticeable effect. This accounts for the fact that the bands are narrow and the intervening spaces comparatively wide. Any general mixture of air of different temperatures or any rippled surface would not produce the shadow band effect such as I witnessed at the recent eclipse. The mixing must be by turbulence or eddies.

In the case of surface winds under consideration there is always more or less turbulence near the ground, due to friction of the current against the ground and also to the interference of obstacles such as trees, houses, etc. Such turbulence, however, might not produce shadow bands in itself, since its temperature is too homogeneous to cause refraction. But during sunlight hours there is always added the vertical convection turbulence due to the air near the ground being unevenly heated and rising. This would make a good shadow producing atmosphere and such shadows would have the direction and approximate velocity of the surface wind. They would originate in the first 500 feet. The shadow bands observed at my location fall into this category.

Of numerous other reports on shadow bands that have come to me either verbally or written, only about half of them, however, are traceable to the surface wind source. Many saw shadow bands in locations where there was no wind. They report velocities from 5 to 20 miles per hour and a general direction of travel from northwest to southeast. The descriptions are, however, still characteristic of the turbulence shadows, dark narrow bands against a lighter ground.

It is only necessary to look a little higher for the source of these bands. They are traveling in the proper general direction to be expected from the Barometric High which was then over the area. Also the general movement of the upper strata as indicated from the clouds was from the northwest quadrant. Under these circumstances of quiet lower strata and rapidly moving higher strata there is usually a thin layer of turbulence between the two. This contact layer between the two strata is full of rolls and eddies caused by the friction and intermixing of the two components. These turbulent regions vary from 100 to 400 feet in thickness. Many of our aviators who are flying regularly find these regions more common than was supposed. Such a turbulent layer is quite usual just under a stratus cloud layer, but when no cloud indicates the contact the turbulent layer can only be detected by flying into it and feeling the characteristic bumping on the wings of the plane. The aviator can reach smooth air by either ascending or descending a few hundred feet.

These turbulent or contact layers are most apt to be encountered at heights between 1000 and 5000 feet although aviators sometimes find them as low as 400 feet. The eddies produced in such layers partake to considerable extent of the direction of the overlying and usually faster-moving stratum. There is almost always a difference of temperature between the two components.

These contact strata of turbulence would therefore produce distinct shadow bands of the same general appearance as those produced by convection turbulence nearer the ground. They appear to explain the general uniformity of motion and direction as well as the appearance of the bands observed in locations without surface winds. The unusual observation of two sets of bands reported from Ithaca probably indicates that both the lower convection turbulence and a higher mixing-strata turbulence were each producing individual series of shadow bands, and therefore tends to corroborate both of the suggested sources.

February 11, 1925.

SHADOW BANDS DURING THE PERIOD OF GREATEST OBSCURATION—PARTIAL ECLIPSE OF THE SUN, PHILADELPHIA, JANUARY 24, 1925.

By HARVEY M. WATTS.

Contrary to what had been asserted in some quarters, that shadow bands were never visible save at totality, the shadow bands at the period of the greatest obscuration of the sun in Philadelphia, during the partial eclipse of January 24, 1925, were marked features of the phenomenon, very clear and distinct. They confirmed the opinion of the writer, gained at the eclipse at Norfolk in 1900, when he was a guest

of Professor Willis L. Moore, Chief of United States Weather Bureau, and confirmed by him later in discussing the matter with H. Helm Clayton of the Blue Hill Observatory, that the shadow bands are due to the boiling motions, slight changes in density, wave motion between contiguous air currents, and the ever-present eddies in the very lowest levels of the atmosphere, and that the motion of the shadow bands is always with the local wind. The variations of the shadow bands in direction, noticed on the spot by observers, are due to the fact that the air, blowing over the inequalities of the ground or around buildings facing in different ways, naturally varies its direction, develops cross currents, and it not only changes its horizontal direction but in some cases, dynamically as well as convectively, may move up the face of a fence or the wall of a building, or may rise up in the open if deflected by any physical cause or any ascent of warm air due to natural convection or artificial convection, such as warm air from chimneys or gratings over heated cellars or basements.

In Philadelphia at the time of the greatest obscuration the general air movement was stiffly from south to north, all the steam and smoke from hotels and skyscrapers in the center of the city, where the observation was made, forming very decided bannerettes moving from south—south by southwest—to north, and this general air motion was without variation during the period of obscuration. When the shadow bands began to appear, which they did as soon as the moments of greatest obscuration arrived, they were noted by the writer on the roof of an apartment house in the center of the city, over which the air was moving freely from the south by reason of no other buildings nearby interfering with the straight south to north movement. Consequently on the flat surface of the roof the shadow bands raced with the wind, save where they flickered somewhat unevenly, so it seemed, because of the disturbance of the air on the south edge of the roof where a line of chimneys was pouring out warm air (invisible). This convective movement set up slight invisible convective eddies which affected the straight horizontal motion of the wind from south to north across the roof and made consequently a slight variation in the appearance of the shadow bands in that section of the roof nearest to the chimneys. A short distance away, about 250 feet, the east wall of a very lofty apartment house faced with cream-colored material showed the shadow bands racing vigorously from south to north, though at the bottom, or the parts nearest the ground, there were evidences of a motion upward as the wind striking the building blew vertically upward and all the variations noticed on the east wall of this apartment house could be explained by variations in the movement of the air normal to the transmission of air current in cities moving among and around and against large, flat surfaces of high buildings.

The shadow bands lasted so long during this period of greatest obscuration that the observer was able to walk down from the apartment house roof, go out on the street, walk up several blocks in order to

notice the effect on some of the larger skyscrapers in the center of the city, 15th and Walnut and 15th and Chestnut Streets. On the wall of a large skyscraper facing eastward the general direction of the very marked bands was from south to north. On a very small three story building on 15th Street facing east, which had just been painted cream color, the shadow bands moved up the building from the lower level to the roof, the air here apparently moving up the face of the building dynamically, and possibly convectively since the basement gratings were opened, out of which warm air was coming. On the southern face of the lofty Packard Building, highest in the city, which, by reason of the buildings to the south of it being low, was a conspicuous mass, the shadow bands raced across it from east to west with slightly rising motions (upward along the face of the material which is cream colored) due to the deflection of the wind from the south, which here struck the southern face of this building without any interference from surrounding structures. In general on all the facades on which the observer noticed the shadow bands moving, and on the street, they moved with the wind or with such deflections of the horizontal or vertical movement of the wind as is to be expected on wall surfaces rising above lower structures in the center of a city or on street surfaces at right angles to the direction of the wind. The duration of the shadow bands impressed the observer, since they kept up as long as the unobscured crescent was relatively small, and consequently they appeared before and during, and continued after, the time of the greatest obscuration.

In expaining to himself the phenomena of the shadow bands seen at Norfolk with the United States Weather Bureau observers, the writer has been in the habit of using the analogy of the flickering effect made on a floor by light shining through a window pane over a steam radiator. Again in the summer of 1900 on comparing eclipse notes with H. Helm Clayton at East Gloucester, Mass., a familiar analogous effect was noticed in a very shallow mass of salt water, over white sand in the shape of flickering wave-like alternations of streaks of light and patches less brilliant on the sandy bottom, caused by the unequal variations in depth of the water produced by the (wave) ripple motions on the surface. These bands of light and shade in the water naturally moved with the wind; that is, they took the direction of the ripple motions produced on the surface of the water by the wind. They seemed to Mr. Clayton and to the writer to be analogous to the eclipse shadow bands, though in the case of the shadow bands in the air we are dealing with rhythmic wave-like inequalities in the density and in the motion of the air in the lowermost strata, where dynamically and convectively all sorts of boiling motions and cross currents are produced, which are familiar to all of us and which, with the sun's light reduced to a crescent or to a few points of light, will produce the shadow band phenomena, since all the variations of motion in the shadow bands that are noted, and all variations as to character or intensity are obviously

due to variations in the motion and density changes in the lowermost currents of air.

This memorandum was sent to Professor Henry Norris Russell of Princeton, Professor Charles Lane Poor of Columbia, Mr. H. Helm Clayton of Canton, Mass., formerly of the Blue Hill Observatory, and to Mr. Alexander McAdie of the Blue Hill Observatory of Harvard, to Professor C. F. Marvin, Chief of the Weather Bureau, Washington, D. C., and to several others, immediately after it was written. Their comment is quite interesting. Professor Russell in referring to the "interesting and valuable observations on the shadow bands" added "I agree entirely that the shadow bands are of atmospheric origin, but am inclined to think that in many cases, particularly in the open country, the irregularities in atmospheric density which produce them may be found at a considerable height above the surface. Your observations in the city indicating that the local irregularities in the air very close to the earth's surface contribute importantly to the phenomena appear convincing." The writer agrees with Professor Russell and has believed all along that wave motions in the upper or lower levels for that matter play their part in the surface effects of the shadow bands. Indeed, it must be obvious that their character and variation and the way they move must be the resultant of all the motions of the atmosphere through which the diminished light passes.

Professor Poor expressed his interest in the report and added very pointedly, that it was very curious that scientists today seemed "to discard all simple and common sense explanations of phenomena and adopt weird and mystical theories in their place." This was apropos of the fact that some of the most ridiculous explanations of shadow band phenomena had appeared in the public prints in New York. Professor Marvin wrote that shadow bands were observed in Washington by members of the Weather Bureau staff, and Professor McAdie, writing of the observance of the partial eclipse in Boston (he was at Readville, ten miles south) says that "the shadow bands were more in the limelight than anything else during the partial eclipse. We saw them distinctly at Readville, 88 miles north of the edge of the totality belt. They moved from west to east and with the wind. Time from 9:15 A. M. to 9:16:50 or about a minute before and a minute after the maximum obscuration. Surface wind velocity 12 miles. I think your observations are all right. The shadow band effects are evidently due to the disturbance of air close to the ground." Mr. H. Helm Clayton writes, "as to the shadow band effects it seems perfectly evident that they are atmospheric because they move with the velocity of and in the direction of atmospheric currents. That they are due to differences in density arising from differences of temperature in adjacent parts of the atmosphere is the most reasonable explanation of their presence. There still remains the question, however, as to whether the differences of temperature which causes them arises from unstable equilibrium in the air, causing ascending and descending currents like those over a hot

stove, or whether they arise from small waves produced by motion between horizontal strata of air of different temperatures, such as are always found in the atmosphere and cause the twinkling of the stars. These waves have been studied by Helmholtz, Exner, Douglass, Pickering and others and there is already a considerable literature on the subject. I am inclined to believe that shadow bands are caused by these waves just as shadow bands are caused on the bottom of shallow pools of water waves such as we saw at East Gloucester in the summer of 1900. At Westerly, R. I., where I saw the shadow bands within the area of totality on January 24, 1925, there was one set of bands moving with the wind and others crossing them at angles so that at times a confused effect was produced. Your observation at Philadelphia, of shadow bands moving up the side of a building and varying direction with the local current, appears to prove that such bands may be caused also by differences of density arising from local heating like that produced by a stove or steam radiator."

REPORT OF THE AMERICAN METEOR SOCIETY FOR 1923 AND 1924.

By C. P. OLIVIER.

Due to the writer's absence on leave from his regular duties during the session of 1923-24, no report on the work of the Society was published at the end of 1923. Hence the present report covers the two years of 1923 and 1924.

While no unusually large amount of observing was done by our members as a whole, yet there was a great gain in the amount of theoretical work done by them and others. Hence the immediate prospects for meteoric astronomy in America were never more promising. In addition to the work of our members, the American Meteor Society now receives, through the courtesy of the Hydrographic Office of the United States Navy, copies of all reports of bright meteors and fireballs sent in by ships' officers. The Superintendent of the United States Weather Bureau also has the kindness to send copies of reports on similar bodies received from meteorological observers, as well as the reports from ships' officers which come directly to the Weather Bureau. The help from these two official sources is steadily growing in volume and value, and grateful acknowledgement is here made to both. Many other individuals, too numerous to mention, have made single reports of similar bodies. Table I contains the names and places of observation of members from whom reports have been received, the number of nights on which observations were made, and the number of meteors observed on these nights. In the cases of several, these

figures are not complete, only those actually coming to this office being here catalogued.

TABLE I.

Alden, H. L.	University, Va.	3	151
Bunch, S.	Fort Worth, Texas	4	77
Cramer, S. M.	Worcester, Mass.	65*	1124
Culp, H. W.	Wolfeboro, N. H.	1*	29
Dole, R. M.	E. Lansing, Mich.	61	1082
Field, G. L.	Worcester, Mass.	5*	77
Mead, P. C.	Des Moines, Iowa	6	188
La Paz, L.	Manitou, Colo.	4	363
La Paz, Mrs. L.		2	56
Olivier, C. P.	University, Va. / Washington, D. C.	7*	300
Peters, J. L.	E. Holliston, Mass.	1	15
Tomkins, T. K.	N. Glenside, Pa.	2	27
Hydrographic Office, U. S. Navy			38
U. S. Weather Bureau			11
Casual			14
Total			3552

*Occasional meteors included in totals.

Table II contains observations of telescopic meteors received since the last report was published or, in one case, found in unpublished records. Nearly all of these were kindly reported by members of the American Association of Variable Star Observers. This help extended the American Meteor Society by a sister organization is of extreme value, and grateful acknowledgement is made to the American Association of Variable Star Observers, as well as to each personal contributor.

TABLE II.

Alden, H. L.	McCormick Obs., Va.	19
Bouton, T. C. H.	St. Petersburg, Fla.	8
Chandler, F. H.	Belgrade Lakes, Maine	3
Chandra, R. G.	Jessore, India	5
Christie, W. H.	Victoria, B. C.	7
Craig, A. P. C.	Corona, Calif.	11
Dawson, B. H.	La Plata Obs., Argentine	6
Ellsworth, F.	Lyons, France	1
Iedema, N.	Great Neck, N. Y.	17
Inglis, W. E.	Bridgeport, Conn.	1
Marshall, R.	Lebanon, Ohio	1
Olivier, C. P.	McCormick Obs., Va.	2
Peltier, L. C.	Delphos, Ohio	163
Skaggs, J. H.	Oakland, Calif.	7
Van der Kamp, P.	McCormick Obs., Va.	1
Total		252

Special attention should be called to the remarkable number seen by Mr. L. C. Peltier. To date (i. e. in three years' interval) he has reported the great total of 274. This is believed to be a record so far as this country is concerned. A special paper will eventually be devoted to the study of the telescopic meteor observations now in our files, and those that we trust will continue to arrive.

Returning to the visual observers, two deserve special mention. Mr. R. M. Dole, an observer of 25 years' experience, writes that nearly every clear night he observes at least one hour for meteors, thus keeping a very continuous watch for any unusual displays. His large totals in Table I refer only to meteors of the brightest and most prominent showers, as he has not reported the nightly observations. His condensed results on these showers have appeared in POPULAR ASTRONOMY during 1923 and 1924 in seven brief articles.

Mr. S. M. Cramer, of Worcester, Mass., who only began active work in June, 1924, before the end of the year had reported the large total of 1124 observations. For one's first six months in the American Meteor Society, this perseverance and success is highly commendable. He has also succeeded in interesting others in the work and has published several notes in POPULAR ASTRONOMY. Results on the Perseid maximum of 1924 by Mr. Sterling Bunch, appeared in the same publication for 1924, page 509. An article by the writer, containing real heights determined from observations by H. L. Alden and himself, as well as a critical discussion of the method used, was published in POPULAR ASTRONOMY, **32**, 591.

In *Observatory* in 1923 the writer also published two short articles about the Orionid radiants of 1922, determined by R. M. Dole, and the photographic radiant by Prof. E. S. King of Harvard College Observatory, all of which proved the said radiant certainly to be in motion and not stationary. The writer succeeded in photographing five meteors at the Perseid maximum of 1923, an encouraging result.

Mr. Lincoln La Paz, one of our most valuable members, has long been engaged in the study of meteor durations as determined by naked-eye estimates. It is hoped that his very important work on this subject will soon appear in print. Mr. W. J. Fisher of Cambridge, Mass., with the collaboration of Dr. H. Shapley, Director of Harvard College Observatory, is now engaged in a critical study of the numerous photographs of meteors contained on the plates taken there. He is also working on the physical theory of meteors. Dr. C. M. Sparrow of the Physics Dept., Univ. of Va., presented at the Washington meeting of the American Astronomical Society the brief outline of a new and most important physical theory of meteors. In working this out he was able to show the errors probably occurring in that of Lindemann and Dobson, which had lead to such remarkable results and had attracted so much attention. The importance of Dr. Sparrow's theory to our whole subject can scarcely be overestimated.

One of the greatest needs of the amateur meteor observer has been a modern book on the general subject. This need the writer has attempted to fill in a book, now about to appear, under the title "Meteors." Both the general history and the theory of the subject have been presented therein. Great numbers of references will point the way to more critical studies.

Finally the American Astronomical Society, acting on the recommendation of the Meteor Committee of the American Section of the International Astronomical Union, has appointed a meteor committee, the personnel of which is as follows: C. P. Olivier, *Chairman;* W. J. Fisher, W. J. Humphreys, G. P. Merrill, and C. M. Sparrow. This committee is directed to encourage meteoric research in every way, and to work toward the establishment of a regular meteor observatory. This, ideally, is to consist of a main and two auxiliary stations, the three a few miles apart, at the vertices of a triangle, and all equipped for the photography and regular study of meteors. This meteor observatory should be located in a favorable part of the United States, and if the funds for its equipment and establishment can be found, we may well expect the most important results, and possibly discoveries in meteoric astronomy within a few years of the beginning of its work. More complete details will be announced when worked out by the committee.

We again call attention of all interested in observational astronomy to the wide field for useful work offered by the study of meteors. To those who desire to take part, full instructions, along with maps and blanks for the work, are furnished on application. New members are always welcomed, and we hope many will join the American Meteor Society during the current year.

Leander McCormick Observatory, University of Virginia,
1925 January 20.

THE APPLICATION OF CALCULATING MACHINES TO ASTRONOMICAL COMPUTING.

By L. J. COMRIE.

It is only within the last twenty years or so that the calculating machine has been so perfected and cheapened that it may by considered as an available implement when dealing with the enormous mass of calculations that astronomers have to face. It is exactly twenty years since Turner, in his familiar *Oxford Note Book* in the *Observatory*, described, almost as a novelty, a comparison he made on a certain piece of work that was done first with logarithms and then with a Brunsviga. The Brunsviga won, taking one third of the time of the other method. But the fact that machines were not generally appreciated at the beginning of the century is shown by Boccardi in his *Guide du Calculateur*, published in 1902, in which he speaks very disparagingly of them, although it is evident from his remarks that his experience was confined to a few of the earlier crude models. For an expression of the present day attitude we may turn to Karl Pearson, who, in a Prefatory

Note to Thompson's *Logarithmetica Britannica,* of which the first volume has just been published, says, "In a certain sense the day of logarithmic tables to 4, 5, 6 or 7 figures is past. The users of such tables are either ignorant of the existence of slide-rules and mechanical calculators, or else unfortunately cannot afford them. Where much computing has to be done logarithms to a few figures are rarely if ever used."

There are perhaps three outstanding reasons why the calculating machine has not made greater inroads into the astronomer's work than it has. Firstly, we have the initial cost of the machines and their mechanical faults. The demand for machines by commercial enterprises is now so great that mass production methods have brought prices down to from $300 to $500 for a first class machine, although of course there are many more expensive types. It is true that earlier models were capable of yielding inaccurate results, but engineering skill has now produced machines that are practically fool proof and error proof, as well as versatile and easy to operate.

Secondly, the great masters of the past, particularly Bessel and Gauss, have bequeathed us a legacy of excellent models of logarithmic calculation, and the astronomical world has in general adopted these. The time is ripe now for someone to show that these logarithmic processes can be *profitably* discarded in favor of natural processes. This does not, in general, mean any added complication, but rather a simplification. We are accustomed to develop a formula from first principles, and then, with the plea of "adapting" it to logarithms, to transform and modify it to gain a slight, and in some cases doubtful, saving of time. If we strip off all the modifications and transformations of many of our present formulæ, getting back to the first principle formulæ, we shall in most cases have just what we want for the machine. The only "adapting" then necessary is that of arrangement—taking advantage of constant multipliers, the cumulative power of the machine, etc.

The third circumstance operating against the more universal adoption of machines is the lack of a good range of tables of the natural values of the trigonometrical functions. The *Opus Palatinum* of Rheticus, published in 1596, gave natural values to ten decimals for every 10″ of arc. But eighteen years later came Napier's invention of logarithms, which were immediately adopted by astronomers. For three centuries the efforts of all table-editors were concentrated on the production of logarithmic tables, culminating in the perfect 8-figure table of Bauschinger and Peters, published 15 years ago. The first evidence that the introduction of machines had revived the necessity for natural tables is Jordan's reprint in 1896 of the sines and cosines of the *Opus Palatinum* to seven decimals. Twelve years later this was followed by Lohse's *Tafeln für numerisches Rechnen mit Maschinen,* an excellent 5-figure table following the decimal division of the degree.

In 1914 Mrs. Gifford commenced the publication of natural tables to eight decimals for every second of arc. Her values were found by interpolation of Rheticus, and her tables would have gone a long way towards filling the existing gap, had it not been for an atrocious arrangement, bad printing, and the fact that the tables already occupy three volumes, with the tangents from 70° to 90° still to appear.

The parent of these tables was the *Opus Palatinum,* 300 years old, and not of established accuracy, especially in the last decimal. Between 1915 and 1918 Andoyer published his three volumes of *Nouvelles Tables Trigonométriques Fondamentales (Valeurs Naturelles),* giving all six functions to fifteen decimals at intervals of 10″. In this splendid work he has laid what should be the foundation of all future natural tables. Peters in 1918 published a 7-figure table for every thousandth of a degree, and has prepared the manuscript of a similar 8-figure table.

But there is still a great deal to be done before our equipment of natural tables is on a par with the splendid range of logarithmic tables that we possess, thus putting us in a position to reap the full benefit of the time and labor saving that can be derived from machines. There should be no difficulty in finding capable persons willing to prepare these tables, but the greater difficulty is to find an institution or publisher willing to defray the expense of preparation and publication, for it is a matter of experience that the sales alone of large tables rarely compensate both author and publisher. With smaller tables, which require little preparation other than arranging, the case is different. It may not be improper to suggest that manufacturers of machines should give some assistance in the matter of financing the publishing of tables, for such enterprise would undoubtedly be to their ultimate advantage.

Outlined below are the titles and synopses of a proposed series of studies in the performance of astronomical computations by machines. Whether these are carried out will depend partly on the expressions of approval* or otherwise with which these suggestions are received, and on the consensus of opinion as to whether the time is yet ripe for the undermining of the old wooden structure of logarithms, and the rebuilding of our methods in the ferro-concrete of machines. That the change is destined to come, and to come before many years have elapsed, is certain.

I. *The Material Available.* A description of the different types of machines available, with the advantages and disadvantages of each. Illustrations (if possible) of the Thomas type, Brunsviga type, Comptometer, Mercedes, Monroe, etc. Comparison of various well known machines on the score of versatility, reliability, speed, portability,

*This paper was read before the American Astronomical Society at Washington on 1924 Dec. 31, and in conversation afterwards quite a number of the astronomers present expressed their appreciation of machines, and a desire to have their capabilities explored.

price, etc. Enumeration and detailed description of tables of natural values of the trigonometrical functions and of reciprocals available. Discussion of plans and schemes for new tables. Decimalisation of the degree.

II. *The Reduction of Photographic Plates.* Perhaps half of the practical work done today in astronomy is photographic, and many least square solutions are made. Illustrations of the reduction of parallax plates and of plates taken for position would be given. Some new tables would be required: these would be computed and given.

III. *Ephemerides of Comets and Minor Planets.* Opposite page illustrations of the old and new methods, with comparison of the times taken by each.

IV. *Solar Eclipses and Lunar Occultations: their Prediction and Reduction.* This is an untouched field, as Bessel's logarithmic method, developed 100 years ago, is still used.

V. *Reduction of Stars from Mean to Apparent Place.* Here again the century old logarithmic method of Bessel occupies the field, but must eventually be displaced. Complete illustrations of the two methods would be given.

VI. *Determination of an Orbit from Three Observations.* This is considered one of the longest and most tedious computations in astronomy. It is certainly one in which a material shortening would be appreciated.

VII. *Interpolation.* This is of interest to others besides those working in astronomy. Use of Everett's central difference formula. Discussion of the special case of interpolating to uniform intervals by determining first the difference that is nearly constant, and then integrating mechanically.

Dearborn Observatory, Evanston, Ill., 1925 February 15.

THIRTY-THIRD MEETING OF THE AMERICAN ASTRONOMICAL SOCIETY.

(Continued from Page 168.)

PHOTOGRAPHS OF MARS AT THE STEWARD OBSERVATORY IN THE 1924 OPPOSITION.

By A. E. Douglass.

During the two years since completion, the 36-inch reflector has been developed towards this end. A device has been worked out by which 15-minute exposures are very successfully obtained. Different plates and color screens were used, ending with red sensitive plates with a red color screen which gives extraordinary contrasts. The sensitiveness is near wave-length 7600. Nearly everything was photographed which

could be seen with the eye in 15-minute drawings. A test of similar plates and color screens was made on a hill 4½ miles distant, representing fairly nearly the thickness of atmosphere through which Mars had been photographed.

CORONAL FORMS IN THE TOTAL ECLIPSE OF SEPTEMBER 10, 1923.

By A. E. Douglass.

On examining the photographs, a very remarkable streamer, or filament of irregular shape, was observed. It had the appearance of rising out of a succession of arches on the southwest limb, and then leaning over in a direction towards or away from us, and finally extending farther away from the sun. The best negative had great differences in density between the areas close to the sun's limb and those farther away. In order to show the continuity in this streamer, photographs were made by indirect illumination as follows: a black disc was placed over the disc of the moon near the original negative; a 75-watt Mazda light was placed behind ground glass about two inches back of this disc; the negative was then photographed through a distant lens. In this manner a great range of density was successfully brought down into the positive.

ATMOSPHERIC CURRENTS.

By A. E. Douglass.

The use of a large mirror gives favorable opportunity for studying certain atmospheric effects. The irregularities in the air due to temperature and density variations appear as moving blotches on the big mirror when the eye-piece is removed and the eye placed at the focus. Some discussion of this by the writer has been published in the *Meteorological Journal,* March, 1895. Subsequent studies give certain forms whose source could be identified. Photographs were made showing the heat currents over a candle, a lamp, a match, currents in full day time also, and artificial shadow bands.

RECENT RESULTS OF TIME DETERMINATIONS AT THE U. S. NAVAL OBSERVATORY.

By J. C. Hammond.

Comparisons of the time determinations made at various observatories by means of wireless time signals show considerable fluctuations. In order to determine whether these fluctuations are due to observational errors peculiar to a certain instrument, the time has been determined at the Naval Observatory with two instruments since November, 1922. These instruments are the six-inch transit circle and a portable

transit of three inches aperture made by Prin of Paris. Both instruments are equipped with impersonal micrometers and with reversing prisms. The instrument houses are about 300 feet apart and are of different types of construction.

The same stars were observed with both instruments each night and the transits were recorded on the same chronograph, so that the comparison is not affected by any errors in the star positions or by any lag of relays. The six-inch was reversed usually between successive time sights and corrections were applied to reduce to the mean of the two clamps. The time stars were all within 18° of the zenith and about the same number of stars were observed north and south of the zenith each night in order to eliminate any error in the azimuth. The latter was determined from observations of circumpolar stars.

The agreement of the two instruments in the determination of the time is good. The differences are entirely too small to explain the fluctuations in the time comparisons. If the latter are due in part to errors in the time determinations, it is probable that such errors arise from local conditions extending over a considerable area and affecting all instruments at an observatory alike.

A GRAPHICAL METHOD FOR DETERMINING THE RADIAL-VELOCITY CORRECTION DUE TO THE EARTH'S MOTION.

By F. Henroteau.

The following graphical method gives the correction v_a for the sun's motion without having to compute the longitude of the star and other constants. It gives an accuracy of one tenth of a kilometer or more and presents several advantages which would encourage its use.

If ϵ and e are the inclination and the eccentricity of the earth's orbit, Γ the sun's longitude at perigee, $90° - i$ the angle between the earth's direction of motion and the radius vector of the orbit, v the mean velocity of the earth in its orbit, it is known that

$$v_a = v \cos\beta \sin(\odot - \lambda) + ve \cos\beta \sin(\Gamma - \lambda), \qquad (1)$$

where λ and β are the longitude and latitude of the star. If v_x, v_y, v_z are the values of v_a for stars situated respectively on the three axes of a rectangular system of coördinates whose origin is the centre of the celestial sphere and whose axes are those for which $\alpha = 0°$ $\delta = 0°$; $\alpha = 90°$ $\delta = 0°$; $\delta = 90°$; we have

$$\begin{aligned} v_x &= v \sin\odot + ve \sin\Gamma \\ v_y &= -v \cos\epsilon \cos\odot - ve \cos\epsilon \cos\Gamma \\ v_z &= -v \sin\epsilon \cos\odot - ve \sin\epsilon \cos\Gamma \end{aligned} \qquad (2)$$

so that if the right ascension and the declination of a star are known, as well as $\odot$ at the time of observation,

$$v_a = v_x \cos\alpha \cos\delta + v_y \sin\alpha \cos\delta + v_z \sin\delta \qquad (3)$$

In the same plane referred to rectangular axes the points A_h (coördinates v_x, v_y) and A_v (coördinates v_x, v_z) are taken. Two circles are drawn having O for centre, one divided into hours and minutes, the other into degrees; on the first B marks the right ascension of the star, on the second C its declination.

Formula (3) leads then to a simple graphical construction for obtaining v_a, much simpler than the direct computation by this formula.

Once for all a graph is made on cross section paper with the two concentric circles mentioned above and with the points A_h and A_v for every degree of solar longitude (graphical interpolation is easy). Over this graph a piece of tracing cloth is used, and v_a is obtained by the following procedure:

Mark on the tracing cloth the points O, B and A_h. Rotate the tracing cloth until OB comes on Ox.

A_v must move on a parallel to Ox and be on the same vertical as A_h. Mark this new A_v^1 on the tracing cloth as well as C. Rotate the tracing cloth until OC coincides with Oy. The ordinate of A_v^1 after this rotation will be v_a, positive if above Ox, negative if below.

As in other methods, corrections for precession will be obtained by subtracting the precession in longitude of the star from the sun's longitude at the moment of observation.

SOME RESULTS OBTAINED WITH THE PRIME VERTICAL TRANSIT.

By George A. Hill.

Volume X, Part I, *Publications of the U. S. Naval Observatory*, Second Series, which is now in press, will contain the observations which have been made by the writer with our prime vertical transit and also a discussion of the results secured.

This work may be divided into three parts.

1. Observations of the declination of the star α Lyrae through a dracontic cycle. The total motion of the moon's node in the period of time covered by the observations is 366°. The purpose was to obtain a correction to the nutation constant. Incident to that there was also derived the absolute parallax of the star as well as corrections to both the adopted aberration and the proper motion of the star.

2. Observations extending over a period of 8 years of the declinations of 16 selected stars, of which α Lyrae was one. These stars were observed in combinations of 4 groups, 4 stars included in each group. As thus indicated they were observed in accordance with the so-called polygon plan, which has the effect of eliminating the variation of latitude from the observed declinations.

3. A list of 368 close zenith stars were observed, the purpose to be accomplished being to secure modern places as well as to ascertain if any not known to have a proper motion in declination were thus affected. Five or more observations were obtained of each star in that list.

The volume will contain 7947 observations made with the instrument, of which 1867 were made of the star α Lyrae.

Results. Below are given values of the aberration which were obtained from a discussion of the work.

Observations of α Lyrae corrected for the variation of latitude,

$$20''.580 \pm 0''.011$$

The 8 years' work using the polygon method,

(1) $20''.542 \pm 0''.010$
(2) 20.550 ± 0.006

Proper motion in declination of α Lyrae, 1900,

Prime vertical	+30″.01
Boss	+27.90
Newcomb	+27.98
Auwers	+29.56

Parallax of α Lyrae. From the observations made after sunset and before sunrise with the star on the meridian there was deduced the following value of the parallax of the star. This is an absolute value and is one of the very few so determined for that star.

$$\pi = +0''.123 \pm 0''.029$$

In observing the 16 stars, using the polygon method, it was found that the probable error of a single latitude was larger when observations were made in the winter time than in the summer.

Nutation. This is the first piece of work in which observed declinations which extend over a dracontic cycle have been corrected for the parallax of the star, aberration, and proper motion, all three of which were derived from the observations before the solution was made to obtain a correction to the value of the nutation used in the reductions. The value of the correction thus found is $+0''.0258 \pm 0''.0143$.

That being applied to Peter's value, namely, 9″.224, gives as the value of the nutation resulting from this work 9″.2498.

Other recent values of the nutation constant are

Newcomb	9″.21	Mean of 27 determinations.
Newcomb	9.214	From the mass of the moon.
Przybyllok	9.2069	International latitude observations.

Reciprocal of the Mass of the Moon. Using the above value of the nutation (9″.2498) and a value of 50″.3731 for the luni-solar precession, the reciprocal of the mass of the moon was found to be 80.54.

A Daylight Term. In *Astronomische Nachrichten,* **201**, No. 4811, Dr. E. Przybyllok has a paper entitled, "Concerning the Meaning of House Refractions in Latitude Determinations." On charts which accompany his paper he shows that observations which have been made with the prime vertical transit at Pulkova; observations which were made of the star α Lyrae with the prime vertical transit at the Naval Observatory in 1862-1867; and later those which were being made with

a similar form of instrument by Prof. Boccardi at Turin, Italy, are all strongly affected with what Dr. Przybyllok calls "house temperature."

The conditions thus existing he makes plain by plotting on the charts certain data which he has computed based upon declinations which were observed with that form of instrument both when the sun was above and when it was below the horizon.

The series of observations which the writer has made of the declinations of α Lyrae with the same form of instrument, and which extends over a much longer period than either of the above, also shows in a very pronounced manner this condition of a change in the value of the declination depending upon whether the observation was made when the sun was above or below the horizon.

A lantern slide was shown upon which had been photographed a chart upon which had been plotted the declinations of α Lyrae for each hour in the day and which corresponds to that hour when the star would be on the meridian. In what follows it should be understood that the hours mentioned correspond to the mean time passage of α Lyrae over the meridian. The star is in R. A. $18^h\ 33^m$ (1900).

These plotted data will be found on a large chart to be inserted in the volume containing the observations. Briefly the minimum declination of the star occurs slightly after noon. From about 8:30 A. M. to noon there is a very sharp drop in the value of the declination at the first hour mentioned amounting to 0".43. The rise in the value of the declination between noon and 5:30 P. M. is almost exactly the same, namely, 0".40.

The important result of this investigation clearly shows that day observations of a star, when they have been made with a prime vertical transit, should not be utilized for the purpose of obtaining corrections to the adopted aberration, the adopted proper motion, the adopted nutation or the parallax of the star.

For that reason the writer did not use those declinations of α Lyrae, in obtaining the data above mentioned, in those cases where the star was observed with sun above the horizon.

He did make a preliminary computation for the parallax of α Lyrae using both day and night determined declinations and obtained one expressed by $+0''.30$, which is purely fictitious.

The constant of nutation, namely, 9".21, which has been adopted in the reduction of star places, is a weighted mean of 27 different determinations. Practically every one of those 27 values was derived from computations in which had been included both day and night observations. That is especially true of those determinations of that constant which are based upon observations which were made with the prime vertical transit.

In addition to the above described chart another one was shown on the same slide. On this latter chart had been plotted latitudes derived from 2484 observed declinations including those made of the star

α Lyrae. All of these declinations had been corrected for variation of the latitude.

The same scheme of exhibiting these varying values of the latitude by hours was used in plotting this chart. Into each mean had been collected all those latitudes the values of which had been derived from observed declinations of stars where the meridian passage of the stars occured between any two hours of mean time. A similar chart to the above with those data plotted on it will also be found in the volume.

A study of these latitudes thus plotted leads to a much stronger conclusion than in the case of those of the declination of α Lyrae, that stars when observed with a prime vertical transit with the sun above the horizon are strongly affected, not with an internal house temperature, but by an influence which exists in the strata of air immediately above the open shutters. The cause for that effect will be taken up in another paper to be read to the Society.

CEPHEIDS IN SPIRAL NEBULAE.

By Edwin P. Hubble.

Messier 31 and 33, the only spirals that can be seen with the naked eye, have recently been made the subject of detailed investigations with the 100-inch and 60-inch reflectors of the Mount Wilson Observatory. Novae are a common phenomenon in M 31, and Duncan has reported three variables within the area covered by M 33.[1] With these exceptions there seems to have been no definite evidence of actual stars involved in spirals. Under good observing conditions, however, the outer regions of both spirals are resolved into dense swarms of images in no way differing from those of ordinary stars. A survey of the plates made with the blink-comparator has revealed many variables among the stars, a large proportion of which show the characteristic light-curve of the Cepheids.

Up to the present time some 47 variables, including Duncan's three, and one true nova have been found in M 33. For M 31, the numbers are 36 variables and 46 novae, including the 22 novae previously discovered by Mount Wilson observers. Periods and photographic magnitudes have been determined for 22 Cepheids in M 33 and 12 in M 31. Others of the variables are probably Cepheids, judging from their sharp rise and slow decline, but some are definitely not of this type. One in particular, Duncan's No. 2 in M 33, has been brightening fairly steadily with only minor fluctuations since about 1906. It has now reached the 15th magnitude and has a spectrum of the bright line B type.

For the determinations of periods and normal curves of the Cepheids, 65 plates are available for M 33, and 130 for M 31. The latter object is too large for the area of good definition on one plate, so attention has been concentrated on three regions: around B D

[1] *Publications of the Astronomical Society of the Pacific*, **35**, 290, 1922.

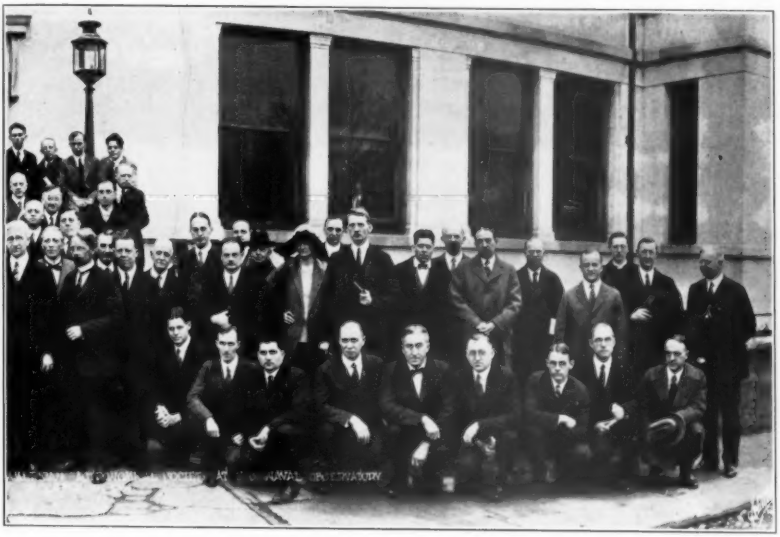
PLATE XVI.

WASHINGTON MEETING OF THE

KEY TO PLATE.

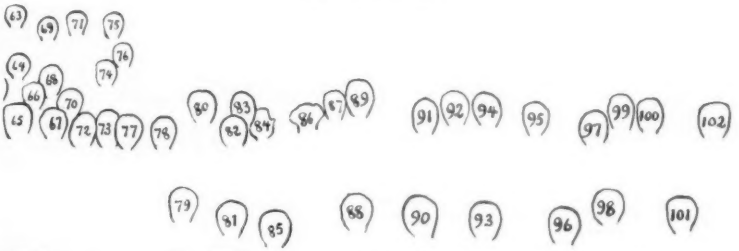
1. H. D. Curtis.
2. Hill.
3. Pitman.
4. Watts.
5. Miss Barney.
6. Mrs. Hedrick.
7. Hussey.
10. Hedrick.
11. Moulton.
12. Manson.
13. Yalden.
14. Boss.
15. Miss Fairfield.
16. Warner.
17. Mrs. Mitchell.
19. Alden.
22. Currier.
23. Mees.
24. Whittaker.
26. Miss France.
27. Stetson.
28. McLaughlin.
29. Mitchell.
30. Morgan.
31. Hammond.
32. Hall.
33. Russell.
34. Robertson.
35. Frost.
38. Rorer.
39. Eichelberger.
40. Littell.
43. Safford.
44. Leuschner.
45. Comrie.
46. Liferock.
47. Ritt.
48. Brigham.
49. Van Biesbroeck.
50. Miss Cannon.
51. Miss Lamson.
52. Hoxton.
53. Miss Walton.
54. Tatlock.

PLATE XVI—CONTINUED.



AMERICAN ASTRONOMICAL SOCIETY.

KEY TO PLATE.



55. Sollenberger.
56. Brown.
57. French.
59. Menzel.
60. Sparrow.
61. Roe.
62. Rogers.
63. Luyten.
64. Bowie.
65. Pollock.
66. Fath.
67. Silberstein.
68. Turner.
69. Urie.
71. Shapley.
72. R. M. Stewart.
73. E. C. Slipher.
74. Henderson.
75. Willis.
76. Pawling.
77. Vanderlinden.
78. Hamilton.
79. Bower.
80. Stokley.
81. Olivier.
82. Vyssotsky.
83. Lambert.
84. Millis.
85. Kiess.
86. Miss Payne.
87. Burton.
88. Humphreys.
89. Alter.
91. Myers.
92. Stebbins.
95. Marriott.
97. Albrecht.
98. R. H. Curtiss.
99. Brock.
100. Slocum.
101. D. R. Curtiss.
102. Peters.

+ 41°151, B D + 40°145, and a region some 45′ along the major axis south preceding the nucleus.

Photographic magnitudes have been determined from twelve comparisons with selected areas No. 21 and 45, made with the 100-inch using exposures from 30 to 40 minutes. This procedure seemed preferable to the much longer exposures required for direct polar comparisons with the 60-inch. It involves, however, a considerable extrapolation based on scales determined from the faintest magnitudes available for the selected areas.

TABLE I.

CEPHEIDS IN M 33.

Var. No.	Period in Days	Log. P	Photographic Magnitudes Max.	Min.
30	46.0	1.66	18.35	19.25
3	41.6	1.62	18.45	19.4
36	38.2	1.58	18.45	19.1
31	37.3	1.57	18.30	19.2
29	37.2	1.57	18.55	19.15
20	35.95	1.56	18.50	19.2
18	35.5	1.55	18.45	19.15
35	31.5	1.50	18.55	19.35
42	31.1	1.49	18.65	19.35
44	30.2	1.48	18.70	
40	26.0	1.41	19.00	
17	23.6	1.37	18.80	
11	23.4	1.37	18.85	
22	21.75	1.34	19.00	
12	21.2	1.33	18.80	
27	21.05	1.32	18.85	
43	20.8	1.32	18.95	
33	20.8	1.32	18.75	
10	19.6	1.29	18.80	
41	19.15	1.28	18.75	
37	18.05	1.26	18.95	
15	17.65	1.25	19.05	

TABLE II.

CEPHEIDS IN M 31.

Var. No.	Period in Days	Log. P	Photographic Magnitude Max.
5	50.17	1.70	18.4
7	45.04	1.65	18.15
16	41.14	1.61	18.6
9	38	1.58	18.3
1	31.41	1.50	18.2
12	22.03	1.34	19.0
13	22	1.34	19.0
10	21.5	1.33	18.75
2	20.10	1.30	18.5
17	18.77	1.28	18.55
18	18.54	1.27	18.9
14	18	1.26	19.1

Tables I and II give the data for the Cepheids in M 33 and M 31 respectively. No magnitudes fainter than 19.5 are recorded, because of the uncertainty involved in their precise determinations. The now

familiar period-luminosity relation is conspicuously present.

For more detailed investigation of the relation, the magnitudes at maxima have been plotted against the logarithm of the period in days. This procedure is necessary, not only because of the uncertainties in the fainter magnitudes, but also because most of the fainter variables at minimum are below the limiting magnitude of the plates. It assumes that there is no relation between period and range, for otherwise a systematic error in the slope of the period-luminosity curve is introduced. Among the brighter Cepheids of M 33 the assumption appears to be allowable, for the ranges show a very small dispersion about the mean value of 0.8 magnitude. The average range and the dispersion are somewhat larger in M 31, but the data are too limited for a complete investigation.

The curve for M 33 appears to be very definite. The average deviation is about 0.1 magnitude, although a considerable systematic error is allowable in the slope. For M 31 the slope is very closely the same but the dispersion is much greater, averaging about 0.2 magnitude. This is probably greater than the accidental errors of measurement.

Shapley's period-luminosity curve[2] for Cepheids, as given in his study of globular clusters, is constructed on a basis of visual magnitudes. It can be reduced to photographic magnitudes by means of his relation between period and color-index, given in the same paper, and the result represents his original data. The slope is of the order of that for the spirals, but is not precisely the same. In comparing the two, greater weight must be given the brighter portion of the curve for the spirals, because of the greater reliability of the magnitude determinations. When this is done, the resulting values of $M - m$ are -21.8 and -21.9 for M 31 and M 33, respectively. These must be corrected by half the average ranges of the Cepheids in the two spirals, and the final values are then on the order of -22.3 for both nebulae. The corresponding distance is about 285,000 parsecs. The greatest uncertainty is probably in the zero point of Shapley's curve.

The results rest on three major assumptions: (1) The variables are actually connected with the spirals. (2) There is no serious amount of absorption due to amorphous nebulosity in the spirals. (3) The nature of Cepheid variation is uniform throughout the observable portion of the universe. As for the first, besides the weighty arguments based on analogy and probability, it may be mentioned that no Cepheids have been found on the several plates of the neighboring selected areas No. 21 and 45, on a special series of plates centered on B D $+ 35°207$, just midway between the two spirals, nor in ten other fields well distributed in galactic latitude, for which six or more long exposures are available. The second assumption is very strongly supported by the small dispersion in the period-luminosity curve for M 33. In M 31, in spite of the somewhat larger dispersion, there is no evidence of an ab-

[2] *Mt. Wilson Contribution* No. 151. *Astrophysical Journal*, **48**, 89, 1918.

sorption effect to be measured in magnitudes.

These two spirals are not unique. Variables have also been found in M 81, M 101 and N. G. C. 2403, although as yet sufficient plates have not been accumulated to determine the nature of their variation.

THE SERIES SYSTEMS OF THE ARC AND SPARK SPECTRA OF ZIRCONIUM.

By C. C. Kiess and Harriet Knudsen Kiess.

Work on the analysis of the spectrum of Zr, of which a brief preliminary report was presented to the Society at the fall meeting in 1923, has been continued, and has been extended to include the spark spectrum as well as the arc spectrum. Owing to the inadequacy of existing tables of wave-length data, the spectrum of Zr was photographed and measured from 2100A in the ultra-violet to 9000A in the near infrared. For this work the quartz prism and concave grating spectrographs of the Bureau of Standards were employed. In addition to the new wave-length data thus acquired, the Zeeman effects of Zr lines as observed by Moore have been of great help in identifying various groups of spectral regularities.

In its general aspects the structure of the spectrum of Zr resembles that of Ti, of which a partial description has already been published by us, and of which a practically complete description has been made by Professor H. N. Russell. The series regularities of the Zr arc spectrum thus far found belong to the triplet and quintet systems; those of the spark spectrum belong to the doublet and quartet systems, in conformity to the displacement law. The multiplets of the Zr spectra are of shorter wave-length than their Ti homologues. This shift is nearly constant, a fact which has been of great help in searching the Zr spectrum for regularities.

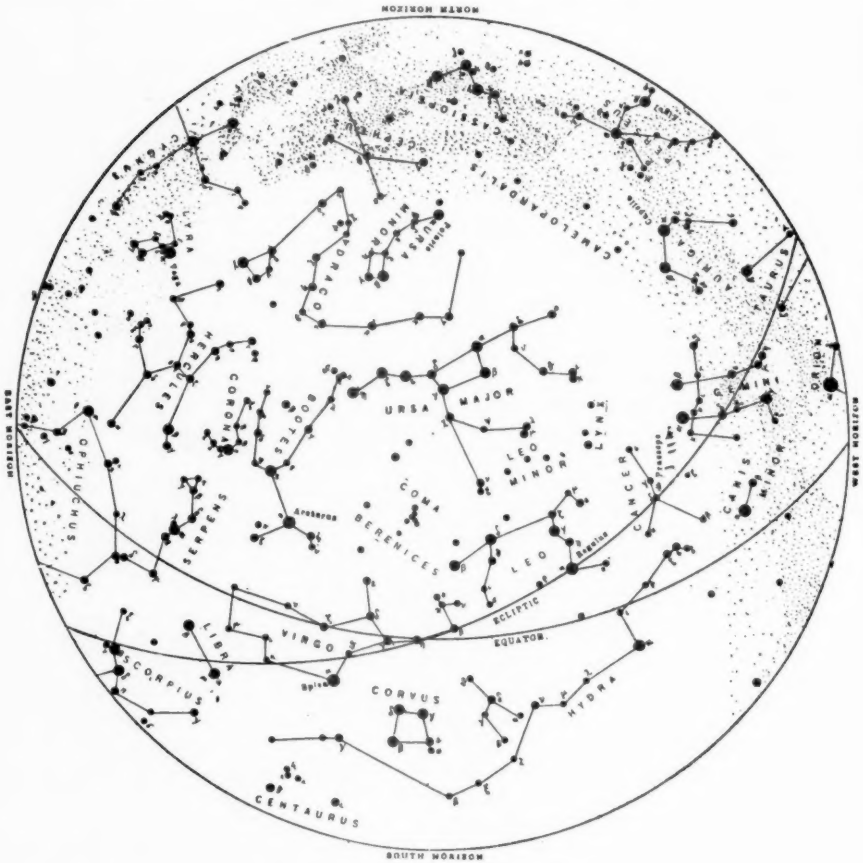
The multiplets of the quintet and triplet systems arise from combinations between S, P, D, F, and G, terms. The lowest level of the quintet system is a 5-fold F term whose components are separated by the frequency differences 348.5, 291.5, 225.7, 153.0. It combines with other D, F, and G, terms. In the triplet system the low triple F term is characterized by the separations 670.5 and 570.4. It combines with other terms to produce FD, FF′, and FG multiplets. The component levels of the low P term of the triplet system are separated by the wave-number intervals 354.6 and 179.5.

In the quartet system the conspicuous multiplets arise from combinations of D, F, and G, terms with two sets of 4-fold F terms between which occur the wave-number differences 559.5, 448.9, 314.4, and 458.0, 404.6, 323.0, respectively. Two triple P terms whose components are separated by 225.8, 189.7 and 322.1, 223.4 combine with S and D terms to form SP and PD groups. In the doublet system the regularities thus far found are limited to combinations of the SP, PP′, and PD types.

(To be continued.)

PLANET NOTES FOR MAY

The *Sun* during the month of May will move northeastward from +14° 51′, $2^h\,31^m$ to 21° 49′, $4^h\,29^m$, and will move from Aries into Taurus. Its course will lie between Aldebaran and the Pleiades. It will be almost directly north of Al-



THE CONSTELLATIONS AT 9:00 P. M. MAY 1.

debaran at the end of the month. The distance between the sun and the earth will be increasing. This may seem strange at first thought to persons in north latitude, that the distance should be increasing at the approach of summer. The fact that the sun is getting farther north, that is higher in the sky, more than counterbalances the increased distance.

The phases of the *Moon* for the month will occur as follows:

First Quarter	May	0 at	9 P.M.	C.S.T.
Full Moon		8 "	8 A.M.	"
Last Quarter		14 "	12 P.M.	"
New Moon		22 "	10 A.M.	"
First Quarter		30 "	2 P.M.	"

The moon will be farthest from the earth on May 26 and nearest on May 11.

Mercury will be moving eastward but much more slowly than the sun during the first half of the month. Consequently on May 16 it will be at a point of greatest elongation west of the sun. On this date it will be more than an hour and a half east of the sun and will therefore be visible near this period as a morning star. It will not be near any bright star at this period.

Venus will be moving eastward a bit more rapidly than the sun. At the end of the month it will cross the meridian less than an hour after the sun and only a few degrees north of the latter. It will therefore be practically invisible during this month.

Mars will cross the meridian between two and three in the afternoon. It will consequently be too low in the sky after sunset for observation during this month. It will continue to move farther from the earth during this period.

Jupiter will cross the meridian on the average at about four o'clock in the morning. Its position will be favorable but the hour rather unfavorable.

Saturn will be at opposition on May 1. It will therefore cross the meridian near midnight and will be a very interesting object for the professional and amateur astronomer as well as for the visitors at the observatories. The earth will be in a position such that the plane of the rings will be inclined at an angle of about 19° with the line of vision. The northern side of the rings will be visible.

Uranus will be between three and four hours west of the sun and will be visible in the early morning. It will be between two and three degrees south of the equator.

Neptune will be in quadrature, 90° east of the sun, on May 11. It will therefore still be visible in the early evening during this month.

Saturn's Satellites.

[From the *American Ephemeris.*]

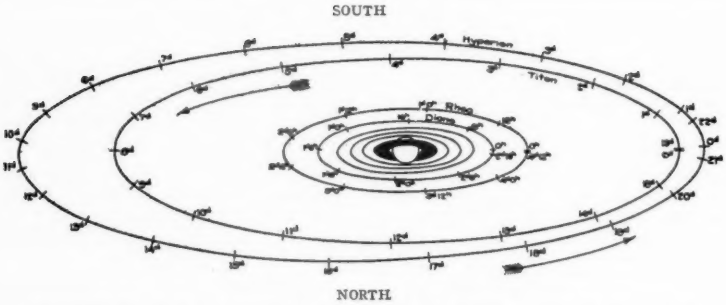
CENTRAL STANDARD TIME, MIDNIGHT = 0^h

I. Mimas. Period $0^d.22^h6$.

1925	d	h		d	h	1925	d	h		d	h
May	1	0.7 W	May	8	2.3 E	May	16	2.6 W	May	24	2.8 E
	1	23.3 W		9	1.0 E		17	1.2 W		25	1.5 E
	2	21.9 W		9	23.6 E		17	23.8 W		26	0.1 E
	3	20.5 W		10	22.2 E		18	22.4 W		26	22.7 E
	4	19.1 W		11	20.8 E		19	21.0 W		27	21.3 E
	5	6.5 E		12	19.4 E		20	19.6 W		28	19.9 E
	6	5.1 E		14	5.4 W		22	5.6 E		29	18.6 E
	7	3.7 E		15	4.0 W		23	4.2 E		31	4.5 W

II. Enceladus. Period $1^d\ 8^h9$.

May	1	11.3 E	May	9	16.5 E	May	17	21.8 E	May	26	3.0 E
	2	20.1 E		11	1.4 E		19	6.6 E		27	11.9 E
	4	5.0 E		12	10.3 E		20	15.5 E		28	20.8 E
	5	13.9 E		13	19.1 E		22	0.4 E		30	5.6 E
	6	22.8 E		15	4.0 E		23	9.3 E		31	14.5 E
	8	7.6 E		16	12.9 E		24	18.1 E			



Apparent orbits of the seven inner satellites of Saturn at date of opposition, May 1, 1925, as seen in an inverting telescope.

III. Tethys. Period $1^d\ 21^h3$.

May	1	4.4 E	May	8	17.6 E	May	16	6.7 E	May	23	19.9 E
	3	1.7 E		10	14.8 E		18	4.0 E		25	17.1 E
	4	23.0 E		12	12.1 E		20	1.3 E		27	14.4 E
	6	20.3 E		14	9.4 E		21	22.6 E		29	11.7 E
										31	9.0 E

IV. Dione. Period $2^d\ 17^h7$.

May	0	23.1 E	May	9	4.0 E	May	17	9.0 E	May	25	13.9 E
	3	16.7 E		11	21.7 E		20	2.6 E		28	7.6 E
	6	10.4 E		14	15.3 E		22	20.3 E		31	1.2 E

V. Rhea. Period $4^d\ 12^h5$.

May	3	17.8 E	May	12	18.4 E	May	21	19.0 E	May	30	19.7 E
	8	6.1 E		17	6.7 E		26	7.4 E			

VI. Titan. Period $15^d\ 23^h3$.

May	7	6.3 W	May	15	3.5 E	May	23	3.7 W	May	31	1.1 E

VII. Hyperion. Period $21^d\ 7^h6$.

May	2	5.9 W	May	12	23.4 E	May	23	10.6 W			

VIII. Japetus. Period $79^d\ 22^h1$.

April	16	3.6 S	May	5	16.7 E	May	24	5.4 I	June	12	16.4 W

NOTE—E, Eastern Elongation; W, Western Elongation; S, Superior Conjunction; I, Inferior Conjunction.

Occultations Visible at Washington.

[*From the American Ephemeris.*]

Date 1925		Star's Name	Magnitude	IMMERSION. Washington C.T.	IMMERSION. Angle from N	EMERSION. Washington C.T.	EMERSION. Angle from N	Duration
				h m	°	h m	°	h m
May	1	ψ Leonis	5.6	23 12	164	23 54	240	0 42
	8	η Librae	5.5	21 47	142	22 50	266	1 3
	10	81 B. Ophiuchi	6.1	4 50	122	5 50	250	1 1
	11	33 Sagittarii	5.8	23 53	85	1 1	287	1 9
	24	64 Orionis	5.1	20 34	136	21 13	229	0 39

VARIABLE STARS.

Minima of Variable Stars of Short Period.

[Calculated by members of the classes in Astronomy at Carleton College.]

Given to the nearest hour in Greenwich civil time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich civil times of minima in 1925 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SY Androm.	0 08.0	+43 09	9.5—13.0	34 21.8					18 22			
RT Sculptor.	31.5	—26 13	9.6—10.5	0 12.3	1 18	9 10	17 2	24 18				
U Cephei	0 52.4	+81 20	7.0— 9.0	1 11.8	3 2	10 13	18 1	25 12				
Z Persei	2 33.7	+41 46	9.4—12	3 01.4	3 18	9 21	22 3	28 5				
TW Cassiop.	37.6	+65 19	8.2— 9.0	1 10.3	5 6	13 19	22 9	30 23				
RY Persei	39.0	+47 43	8.0—10.3	6 20.7	4 16	11 12	18 9	25 6				
RZ Cassiop.	39.9	+69 13	6.9— 8.1	1 04.7	7 20	15 0	22 4	29 8				
TX Cassiop.	44.4	+62 22	9.4—10.1	2 22.2	9 17	18 12	27 7					
ST Persei	53.7	+38 47	8.5—10.5	2 15.6	1 4	9 2	17 1	25 0				
RX Cassiop.	2 58.8	+67 11	8.6— 9.1	32 07.6				26 20				
Algol	3 01.7	+40 34	2.3— 3.5	2 20.8	6 14	15 5	23 19					
RT Persei	16.7	+46 12	9.5—11.5	0 20.4	5 23	12 18	19 13	26 8				
λ Tauri	55.1	+12 12	3.3— 4.2	3 22.9	3 10	11 8	19 5	27 3				
RW Tauri	3 57.8	+27 51	7.1— [11	2 18.5	8 0	16 7	24 15					
RV Persei	4 04.2	+33 59	9.5—11.0	1 23.4	3 5	11 3	19 0	26 22				
RW Persei	13.3	+42 04	8.8—11.0	13 04.8		10 20		24 1				
SZ Tauri	31.4	+18 20	7.2— 7.7	3 03.6	4 6	10 13	23 3	29 10				
RS Cephei	4 48.6	+80 06	9.5—12.0	12 10.1		11 17	24 3					
TT Aurigae	5 02.8	+39 27	7.8— 8.7	0 16.0	2 8	9 0	22 7	28 23				
RY Aurigae	11.5	+38 13	10.7—11.7	2 17.5	2 10	10 14	18 18	26 23				
RZ Aurigae	42.9	+31 40	10.6—13.3	3 00.3	4 20	10 20	22 21	28 22				
SV Tauri	45.8	+28 05	9.4—11.0	2 04.0	3 10	12 2	20 18	29 10				
Z Orionis	50.2	+13 40	9.7—10.7	5 04.9	4 6	14 16	25 2					
SV Gemin.	54.6	+24 28	9.8— [11	4 00.2	8 10	16 11	24 11					
RW Gemin.	5 55.4	+23 08	9.5—11.0	2 20.8	3 21	9 15	21 2	26 19				
U Columbæ	6 11.2	—33 03	9.2—10.0	2 19.2	4 12	10 3	21 7	26 22				
SX Gemin.	22.0	+20 37	10.8—11.5	1 08.8	7 0	15 5	23 10	31 14				
RW Monoc.	29.3	+ 8 54	9.0—10.8	1 21.7	5 6	12 21	20 12	28 3				
RX Gemin.	43.6	+33 21	8.8— 9.6	12 05.0		11 9	23 14					
RU Monoc.	6 49.4	— 7 28	9.8—10.5	0 21.5	5 3	12 7	19 12	26 16				
R Can. Maj.	7 14.9	—16 12	5.8— 6.4	1 03.3	7 1	13 21	20 16	27 12				
RY Gemin.	21.7	+15 52	8.9— [10	9 07.2	4 1	13 9	22 16	31 23				
Y Camelop.	27.6	+76 17	9.5—12	3 07.3	2 8	8 23	22 4	28 19				
TX Gemin.	30.3	+17 08	10.0—11.9	2 19.2	4 19	13 5	21 14	30 0				
RR Puppis	43.5	—41 08	9.4—10.7	6 10.3	3 21	10 7	23 4	29 14				
V Puppis	7 55.4	—48 58	4.1— 4.8	1 10.9	1 4	8 10	22 23	30 6				
X Carinae	8 29.1	—58 53	7.9— 8.7	0 13.0	7 3	15 6	23 8	31 11				
S Cancri	8 38.2	+19 24	8.2—10	9 11.6	5 6	14 18	24 6					
RX Hydrae	9 00.8	— 7 52	9.1—10.5	2 06.8	5 3	11 23	18 20	25 16				
S Velorum	29.4	—44 46	7.8— 9.3	5 22.4	1 2	12 23	18 21	30 18				
Y Leonis	9 31.1	+26 41	9.3—11.2	1 16.5	2 5	8 23	22 11	29 5				
RR Velorum	10 17.8	—41 36	10.0—10.9	1 20.5	3 13	10 23	18 9	25 19				
SS Carinæ	10 54.2	—61 23	12.2—12.8	3 07.2	3 13	10 3	23 8	29 23				
ST Urs. Maj.	11 22.4	+45 44	6.7— 7.2	8 19.2	4 2	12 21	21 16	30 12				
RW Urs. Maj.	35.4	+52 34	10.3—11.4	7 07.9	8 0	15 8	22 16	30 0				
Z Draconis	1 39.8	+72 49	9.9—13.6	1 08.6	2 12	9 7	22 21	29 16				
RZ Centauri	12 55.6	—64 05	8.5— 8.9	1 21.0	5 9	12 21	20 9	27 22				
RS Can. Ven	13 06.3	+36 28	7.5—12.5	4 19.1	9 8	18 23	28 13					
SS Centauri	07.2	—63 37	8.8—10.4	2 11.5	4 17	12 4	19 14	27 1				
SX Hydræ	13 39.0	—26 23	8.6—12.7	2 21.5	6 12	12 7	23 21	29 16				

Minima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich civil times of minima in 1925							
					May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
δ Libræ	14 55.6	— 8 07	4.8— 6.2	2 07.9	6 3	13 3	20 3	27 2				
U Coronæ	15 14.1	+32 01	7.6— 8.7	3 10.9	3 7	10 5	24 0	30 22				
TW Draconis	15 32.4	+64 14	7.3— 8.9	2 19.4	2 0	10 10	18 20	27 6				
SS Libræ	15 43.4	—15 14	9.3—11.5	0 18.4	7 3	14 8	21 12	28 17				
SW Ophiuchi	16 11.1	— 6 44	9.2—10.0	2 10.7	5 9	12 17	20 1	27 9				
SX Ophiuchi	12.6	— 6 25	10.5—11.2	2 01.5	9 5	17 11	25 17					
R Aræ	31.1	—56 48	6.8— 7.9	4 10.2	3 6	12 3	20 23	29 19				
TT Herculis	16 49.9	+17 00	8.9— 9.3	20 18.1	5 9		26 3					
TU Herculis	17 09.8	+30 50	9.5—12	2 06.4	6 14	13 9	20 4	27 0				
U Ophiuchi	11.5	+ 1 19	6.0— 6.7	0 20.1	6 0	14 9	22 18	31 4				
u Herculis	13.6	+33 12	4.6— 5.4	2 01.2	6 11	12 14	24 21	31 1				
TX Herculis	15.4	+42 00	8.3— 9.0	1 00.7	2 22	9 2	21 11	27 15				
RV Ophiuchi	29.8	+ 7 19	9. —12	3 16.5	7 3	14 11	21 20	29 6				
SZ Herculis	36.0	+33 01	9.5—10.3	0 19.6	1 12	9 17	17 21	26 1				
TX Scorpii	48.6	—34 13	7.5— 8.2	0 22.6	6 17	14 6	21 19	29 7				
UX Herculis	49.7	+16 57	8.8—10.5	1 13.2	3 3	10 21	18 15	26 8				
Z Herculis	53.6	+15 09	7.1— 7.9	3 23.8	7 15	15 15	23 14	31 14				
WX Sagittarii	53.6	—17 24	9.2—10.8	2 03.1	3 6	11 19	20 7	28 20				
WY Sagittarii	17 54.9	—23 01	9.5—10.6	4 16.0	3 3	12 12	21 20	31 4				
SX Draconis	18 03.0	+58 23	9.3—10.5	5 04.1	6 2	16 10	21 14	31 22				
RS Sagittarii	11.0	—34 08	5.9— 6.3	2 10.0	4 17	11 23	19 5	26 11				
V Serpentis	11.1	—15 34	9.5—11.1	3 10.9	1 22	8 20	22 16	29 14				
RZ Scuti	21.1	— 9 15	7.4— 8.3	15 03.2		14 10		29 13				
RZ Draconis	21.8	+58 50	9.5—10.2	0 13.2	1 17	8 22	23 5	30 9				
RX Herculis	26.0	+12 32	7.0— 7.6	0 21.3	5 6	12 9	19 12	26 14				
SX Sagittarii	39.7	—30 36	8.7— 9.8	2 01.8	5 1	13 9	21 16	30 0				
RR Draconis	40.8	+62 34	9.3—13	2 19.9	9 11	17 23	26 11					
RS Scuti	43.7	—10 21	9.3—10.3	0 15.9	3 3	9 19	23 2	29 17				
β Lyræ	46.4	+33 15	3.4— 4.1	12 21.8		7 1	19 23					
U Scuti	18 48.9	—12 44	9.1— 9.6	0 22.9	8 9	16 1	23 16	31 7				
RX Draconis	19 01.1	+58 35	9.3—10.2	1 21.4	5 17	13 6	20 20	28 10				
RV Lyræ	12.5	+32 15	11. —12.8	3 14.4	3 20	11 0	18 5	25 10				
RS Vulpec.	13.4	+22 16	6.9— 8.0	4 11.4	7 19	16 18	25 17					
U Sagittæ	14.4	+19 26	6.5— 9.0	3 09.1	3 3	9 21	23 10	30 4				
Z Vulpec.	17.5	+25 23	7.3— 8.5	2 10.9	7 6	14 15	21 23	29 8				
TT Lyræ	24.3	+41 30	9.4—11.6	5 05.8	3 15	14 3	19 9	29 20				
UZ Draconis	26.1	+68 44	9.0— 9.8	1 15.1	6 13	13 2	19 14	26 3				
SY Cygni	19 42.7	+32 28	10. —12	6 00.2	1 2	13 2	19 2	31 2				
WW Cygni	20 00.6	+41 18	9.3—13.4	3 07.6	6 11	13 2	19 17	26 9				
SW Cygni	03.8	+46 01	9. —11.7	4 13.8	5 4	14 7	18 22	28 1				
VW Cygni	11.4	+34 12	9.8—11.8	8 10.3	2 15	11 2	19 12	27 22				
RW Capric.	12.2	—17 59	8.8—10.6	3 09.4	6 16	13 11	20 6	27 1				
UW Cygni	19.6	+42 55	10.5—13	3 10.8	2 4	9 2	22 21	29 19				
V Vulpec	32.3	+26 15	8.2— 9.8	37 19.0	1 5							
W Delphini	33.1	+17 56	9.4—12.1	4 19.4	6 19	16 10	26 1					
RR Delphini	38.9	+13 35	10.5—11.8	4 14.4	7 7	16 12	25 17					
Y Cygni	48.1	+34 17	7.1— 7.9	1 12.0	5 17	14 17	23 16					
WZ Cygni	49.3	+38 27	9.9—10.8	0 14.0	7 13	15 3	22 18	30 8				
RR Vulpec	20 50.5	+27 32	9.6—11.0	5 01.2	2 16	12 19	22 21					
RY Aquarii	21 14.8	—11 14	8.8—10.4	1 23.2	2 3	9 23	17 20	25 17				
UZ Cygni	55.2	+43 52	8.9—11.6	31 07.3		19 1						
RT Lacertæ	21 57.4	+43 24	9.1—10.5	5 01.7	3 9	13 12	23 16					
RW Lacertæ	22 40.6	+49 08	10.2—11.2	5 04.4	2 3	12 12	17 16	28 1				
VW Pegasi	51.7	+32 42	10.0—10.6	5 06.4	3 12	14 1	19 7	29 20				
Y Piscium	23 29.3	+ 7 22	9.0—12.0	3 18.4	1 1	8 13	23 15	31 4				
TW Androm.	23 58.2	+32 17	8.6—11.5	4 02.9	2 20	11 1	19 7	27 13				

Maxima of Variable Stars of Short Period.

[Calculated by members of the classes in Astronomy at Carleton College.]

Given to the nearest hour in Greenwich civil time; to obtain Eastern Standard time subtract 5^h; Central Standard time 6^h, etc.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich civil times of maxima in 1925							
					May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
SX Cassiop.	0 05.5	+54 20	8.6— 9.2	36 13.7	4 16							
SY Cassiop.	0 09.8	+57 52	9.3— 9.9	4 01.7	8 3	16 6	24 10					
RR Ceti	1 27.0	+ 0 50	8.3— 9.0	0 13.3	4 9	12 3	19 21	27 15				
RW Cassiop.	1 30.7	+57 15	8.9—11.0	14 19.2		14 10	29 5					
V Arietis	2 09.6	+11 46	8.3— 9.0	0 23.8	5 2	13 1	20 23	28 22				
SU Cassiop.	2 43.0	+68 28	6.5— 7.0	1 22.8	3 15	11 10	18 5	27 0				
RW Camelop.	3 46.2	+58 21	8.2— 9.4	16 00.0		16 12						
SX Persei	4 10.2	+41 27	10.4—11.2	4 07.0	1 12	10 2	18 16	27 6				
SV Persei	42.8	+42 07	8.8— 9.6	11 03.1	3 17	14 21	26 0					
RX Aurigæ	4 54.5	+39 49	7.2— 8.1	11 15.0	9 8		20 23					
SX Aurigæ	5 04.6	+42 02	8.0— 8.7	1 12.8	1 10	9 2	16 18	24 10				
SY Aurigæ	05.5	+42 41	8.4— 9.5	10 03.3		10 4	20 8	30 11				
Y Aurigæ	21.5	+42 21	8.6— 9.6	3 20.6	3 14	11 7	19 1	26 18				
RZ Gemin.	5 56.6	+22 15	9.1—10.0	5 12.7	3 13	14 14	20 3	31 4				
RS Orionis	6 16.5	+14 44	8.2— 8.9	7 13.6	4 9	11 23	19 12	27 2				
T Monoc.	19.8	+ 7 08	5.7— 6.8	27 00.3	3 4			30 4				
RT Aurigæ	23.0	+30 33	5.1— 6.0	3 17.5	1 4	8 15	16 2	23 13				
W Gemin.	29.2	+15 24	6.7— 7.5	7 22.0	7 1	14 23	22 21	30 19				
ζ Gemin.	6 58.2	+20 43	3.7— 4.3	10 03.7	4 10	14 14	24 18					
RU Camelop	7 10.9	+69 51	8.5— 9.8	22 06.5	8 5			30 12				
RR Gemin.	7 15.2	+31 04	10.0—11.5	0 09.5	5 22	13 21	21 19	29 18				
V Carinae	8 26.7	—59 47	7.4— 8.1	6 16.7	2 5	8 22	22 7	28 23				
T Velorum	8 34.4	—47 01	7.6— 8.5	4 15.3	2 20	12 3	21 10	30 16				
V Velorum	9 19.2	—55 32	7.5— 8.2	4 08.9	8 17	17 11	26 5					
Z Leonis	9 46.4	+27 22	7.9— 9.6	56 08.7								
RR Leonis	10 02.1	+24 29	9.1—10.1	0 10.9	6 2	12 21	19 16	26 11				
SU Draconis	11 32.2	+67 53	8.9— 9.6	0 15.8	1 9	7 23	21 5	27 19				
S Muscae	12 07.4	—69 36	6.4— 7.3	9 15.8	9 23	19 16	29 7					
SW Draconis	12.8	+70 04	8.8— 9.6	0 13.7	4 21	12 20	20 19	28 19				
T Crucis	15.9	—61 44	6.8— 7.6	6 17.6	7 21	14 14	21 8	28 1				
R Crucis	18.1	—61 04	6.8— 7.9	5 19.8	6 16	12 11	24 3	29 23				
S Crucis	12 48.4	—57 53	6.5— 7.6	4 16.6	4 22	14 7	19 23	28 8				
W Virginis	13 20.9	— 2 52	8.7—10.4	17 06.5		9 9	26 16					
SS Hydræ	25.0	—23 08	7.4— 8.1	8 04.8	4 12	12 17	20 22	29 3				
RV Urs. Maj.	13 29.4	+54 31	9.2— 9.9	0 11.2	8 0	15 1	22 1	29 2				
ST Virginis	14 22.5	— 0 27	10.3—11.4	0 09.9	7 19	15 4	22 14	30 0				
V Centauri	25.4	—56 27	6.4— 7.8	5 11.9	1 8	12 7	17 19	28 19				
RS Bootis	29.3	+32 11	8.9—10.0	0 09.1	3 5	10 18	18 7	25 20				
R Triang.Austr.	15 10.8	—66 08	6.7— 7.4	3 09.3	3 22	10 16	24 6	31 0				
S Triang.Austr.	15 52.2	—63 29	6.4— 7.4	6 07.8	3 15	9 22	22 14	28 22				
S Normæ	16 10.6	—57 39	6.6— 7.6	9 18.1	4 8	14 2	23 20					
RW Draconis	33.7	+58 03	9.6—10.8	0 10.6	2 8	11 4	20 1	28 21				
RV Scorpii	16 51.8	—33 27	6.7— 7.4	6 01.5	6 11	12 12	24 15	30 17				
X Sagittarii	17 41.3	—27 48	4.4— 5.0	7 00.3	5 1	12 1	19 2	26 2				
Y Ophiuchi	47.3	— 6 07	6.1— 6.5	17 02.9	3 14		20 17					
W Sagittarii	17 58.6	—29 35	4.3— 5.1	7 14.3	3 7	10 22	18 12	26 2				
Y Sagittarii	18 15.5	—18 54	5.4— 6.2	5 18.6	2 18	8 12	20 2	25 20				
U Sagittarii	26.0	—19 12	6.5— 7.3	6 17.9	6 4	12 22	29 16	26 10				
Y Scuti	32.6	— 8 27	8.7— 9.2	10 08.3	3 15	13 23	24 7					
RZ Lyræ	39.9	+32 42	9.9—11.2	0 12.3	8 6	15 22	23 14	31 7				
RT Scuti	18 44.1	—10 30	9.1— 9.7	0 11.9	1 1	8 12	23 9	30 19				
κ Pavonis	18 46.6	—67 22	3.8— 5.2	9 02.2	5 3	14 6	23 8					
U Aquilæ	19 24.0	— 7 15	6.2— 6.9	7 00.6	3 18	10 19	24 20	31 20				

Maxima of Variable Stars of Short Period—Continued.

Star	R.A. 1900	Decl. 1900	Magnitude	Approx. Period	Greenwich civil times of maxima in 1925 May							
	h m	° ′		d h	d h	d h	d h	d h	d h	d h	d h	d h
XZ Cygni	19 30.4	+56 10	8.6— 9.3	0 11.2	4 6	11 6	18 6	25 6				
U Vulpec.	32.2	+20 07	6.5— 7.6	7 23.5	8 13	16 12	24 12					
SU Cygni	40.8	+29 01	6.2— 7.0	3 20.3	7 20	15 12	23 5	30 22				
η Aquilæ	47.4	+ 0 45	3.7— 4.5	7 04.2	8 2	15 6	22 11	29 15				
S Sagittæ	51.5	+16 22	5.6— 6.4	8 09.2		9 4	17 13	25 23				
X Vulpec.	19 53.3	+26 17	9.5—10.5	6 07.7	5 11	11 18	24 10	30 17				
X Cygni	20 39.5	+35 14	6.0— 7.0	16 09.3		11 16	28 1					
T Vulpec.	47.2	+27 52	5.5— 6.1	4 10.5	2 21	11 18	20 15	29 12				
UY Cygni	52.3	+30 03	9.6—10.4	0 13.5	6 21	13 15	20 8	27 2				
RV Capric.	55.9	—15 37	9.2—10.1	0 10.7	5 17	12 10	19 3	25 20				
TX Cygni	20 56.4	+42 12	8.5— 9.7	14 17.4		6 18	21 11					
VY Cygni	21 00.4	+39 34	8.8— 9.5	7 20.6	6 21	14 17	22 14	30 11				
SW Aquarii	10.2	— 0 20	9.9—10.8	0 11.0	6 12	13 10	20 6	27 5				
VZ Cygni	21 47.7	+42 40	8.2— 9.2	4 20.7	4 13	14 7	19 4	28 21				
Y Lacertæ	22 05.2	+50 33	9.1— 9.6	4 07.8	6 9	15 1	23 16					
δ Cephei	25.5	+57 54	3.7— 4.6	5 08.8	4 14	15 8	20 16	31 10				
Z Lacertæ	36.9	+56 18	8.2— 9.0	10 21.1	9 21	20 19	31 16					
RR Lacertæ	37.5	+55 55	8.5— 9.2	6 10.1	4 21	11 7	24 3	30 12				
V Lacertæ	44.5	+55 48	8.5— 9.5	4 23.6	5 20	15 19	20 19	30 18				
X Lacertæ	22 45.0	+55 54	8.2— 8.6	5 10.7	3 9	15 6	20 17	31 14				
SW Cassiop.	23 03.7	+58 11	9.2— 9.7	5 10.6	1 10	12 7	17 18	27 15				
RS Cassiop.	32.6	+61 52	9.0—11.0	6 07.1	1 6	7 13	20 4	26 11				
RY Cassiop.	47.2	+58 11	9.3—11.8	12 03.4	1 9	13 12	25 15					
V Cephei	23 51.7	+82 38	6.0— 7.0	0 23.9	4 18	11 18	18 17	25 17				

Monthly Report of the American Association of Variable Star Observers, Received During February, 1925.

Once again the Association records the sudden passing of another of its members, Mr. John A. Parkhurst, late Professor of Astronomy at the Yerkes Observatory, a pioneer in variable star observing, and one of the first three Honorary Members elected by the Council of the AAVSO. Professor Parkhurst ever manifested a deep interest in the efforts of the Association and we have been favored, for several years past, with frequent reports of observations from him as made with the great 40-inch refractor. He made a great name for himself in variable star astronomy and his advice was sought on many occasions by many a tyro in our chosen line of research. To his family and his co-workers at Yerkes we extend our deepest sympathies.

Although cloudy weather has interfered somewhat with the quantity of our results, a perusal of the table will show that quality has not suffered, and the continuity of observations is most creditable to the zeal of our observers. We welcome the first report from our new member in far off Japan, Mr. P. M. Millman. Professor W. K. Greene, Director of the Amherst Observatory has joined our ranks. He plans extensive work on variable stars and their comparison stars with the 18-inch telescope, so well used in former years for variable star observing by Professor Todd and our own Mr. C. J. Hudson, now of Worcester, Mass.

As stated in previous reports, all observations made prior to January 1, 1925, Jul. Day 2425152, are referred to Greenwich Mean Noon, while those made after that date are referred to Greenwich Civil Time (Greenwich Midnight).

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925.

December 1, 1924 = J. D. 2424121. January 1, 1925 = J. D. 2424152.
February 1, 1925 = J. D. 2424183.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
000339 V SCULPTORIS—						
	4121.0	12.1	Bl	4137.0	12.7	Bl
001032 S SCULPTORIS—						
	4120.9	6.8	Kk	4142.4	7.4	Sm
	4121.0	6.5	Bl	4144.0	7.4	Bl
	4122.9	6.8	Kk	4147.9	7.7	Kd
	4124.4	6.7	Sm	4150.4	7.5	Sm
	4129.1	6.9	Bl	4164.4	8.1	Kd
	4132.9	7.1	Kk	4170.4	8.0	Kd
	4136.4	7.1	Sm	4172.0	8.1	Pt
	4137.0	7.1	Bl			
001046 X ANDROMEDAE—						
	4164.2	12.8	Wf	4187.4	13.1	Bi
	4175.1	13.1	Wf	4195.1	13.9	Wf
	4176.7	12.7	Bi	4196.1	13.6	Lv
	4181.3	12.8	Bi			
001620 T CETI—						
	4120.9	6.5	Kk	4147.9	6.6	Kd
	4122.9	6.5	Kk	4154.4	6.5	Kd
	4123.9	6.5	Kk	4164.4	6.4	Kd
	4127.9	6.4	Kk	4167.4	6.2	Kd
	4129.9	6.4	Kk	4170.4	6.1	Kd
	4132.9	6.5	Kk	4174.4	6.1	Kd
	4137.9	6.5	Kk	4174.7	5.6	L
001726 T ANDROMEDAE—						
	4168.1	9.2	B	4187.3	10.0	Bi
	4172.1	9.2	Pt	4194.1	10.8	B
	4176.8	9.1	Bi	4197.1	11.0	Lv
	4182.0	9.6	Ie			
001755 T CASSIOPEIAE—						
	4168.1	7.8	B	4182.1	7.5	Jo
	4168.9	7.4	L	4196.1	7.9	Jo
	4172.1	7.9	Pt	4197.3	8.9	Sg
	4172.1	6.9	Jo			
001838 R ANDROMEDAE—						
	4172.1	14.3	Pt	4186.0	[12.4	Cd
001862 S TUCANAE—						
	4121.0	8.9	Bl	4137.0	9.4	Bl
	4122.3	9.4	Sm	4142.3	10.0	Sm
	4129.1	9.1	Bl	4144.0	10.0	Bl
	4136.3	9.3	Sm	4149.4	10.2	Sm
001909 S CETI—						
	4172.1	12.8	Pt	4174.8	12.9	L
002546 T PHOENICIS—						
	4136.4	12.7	Sm	4144.0	12.5	Bl
	4137.0	13.4	Bl	4149.4	11.6	Sm
	4142.3	12.5	Sm			
002833 W SCULPTORIS—						
	4137.0	13.0	Bl			
003179 Y CEPHEI—						
	4168.0	10.4	B			
004047 U CASSIOPEIAE—						
	4168.1	10.1	B	4195.1	12.6	Wf
	4172.1	10.6	Pt	4196.1	12.4	Lv
	4176.0	10.5	Bi	4197.3	[12.1	Sg
	4191.2	12.0	Wf			
004132 RW ANDROMEDAE—						
	4172.1	9.0	Pt	4181.1	9.7	B
	4180.0	9.6	Ie			
004435 V ANDROMEDAE—						
	4176.6	9.4	Bi	4195.0	9.1	B
	4187.4	9.1	Bi	4196.1	9.3	Lv
004533 RR ANDROMEDAE—						
	4181.1	13.1	B	4195.1	13.8	Wf
004435 X SCULPTORIS—						
	4121.1	13.1	Bl	4144.0	12.6	Bl
	4137.0	12.8	Bl			
004746a RV CASSIOPEIAE—						
	4172.1	12.9	Pt	4195.1	13.8	Wf
	4181.1	13.0	B			
004746b — CASSIOPEIAE—						
	4172.1	10.8	Pt			
004958 W CASSIOPEIAE—						
	4172.1	11.8	Pt	4195.1	10.3	B
	4180.1	11.1	B			
005475 U TUCANAE—						
	4121.0	10.5	Bl	4137.0	11.1	Bl
	4122.3	10.8	Sm	4142.3	11.8	Sm
	4129.1	10.8	Bl	4144.0	11.6	Bl
	4136.3	11.6	Sm	4149.4	11.9	Sm
005840 RX ANDROMEDAE—						
	4166.1	11.8	Br	4188.1	[12.0	Pt
	4172.1	13.6	Pt	4189.0	[11.0	Pt
	4173.0	13.5	Pt	4190.0	[11.0	Pt
	4175.1	13.7	Br	4195.2	11.2	Br
	4179.1	11.0	Pt	4196.0	[11.5	Pt
	4181.1	[12.4	Pt	4198.0	[12.6	Pt
	4182.0	[12.4	Pt	4200.0	13.5	Pt
	4187.2	[11.0	Pt	4201.0	13.6	Pt
010102 Z CETI—						
	4172.1	13.5	Pt	4194.0	[13.0	B
010630 U SCULPTORIS—						
	4121.0	10.8	Bl	4137.0	11.0	Bl
	4129.1	10.8	Bl	4144.0	11.5	Bl
010940 V ANDROMEDAE—						
	4174.0	13.2	Ie			
011041 UZ ANDROMEDAE—						
	4175.0	13.2	Ie	4195.1	13.7	Wf
011208 S PISCIUM—						
	4168.1	12.2	B	4201.1	[12.0	Y
011272 S CASSIOPEIAE—						
	4167.9	12.3	Bi	4196.0	12.5	Pt
	4168.1	12.8	B	4196.1	12.3	Lv
011712 U PISCIUM—						
	4172.1	11.5	Pt			
012233a R SCULPTORIS—						
	4147.9	7.5	Kd	4167.4	7.4	Kd
012350 RZ PERSEI—						
	4168.1	10.0	B	4197.1	10.2	Y
	4194.1	10.2	B			

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
012502 R PISCIUM—				
	4173.1	12.8 Bi	4196.0	10.4 Pt
	4187.0	11.5 Bi	4201.1	9.4 Y
	4193.0	11.1 Bi		
013238 RU ANDROMEDAE—				
	4172.1	14.2 Pt	4182.0	[12.7 Ie
	4181.1	13.1 B	4195.2	13.8 Wf
013338 Y ANDROMEDAE—				
	4168.1	12.8 B	4195.1	[13.6 B
	4172.1	13.3 Pt		
014958 X CASSIOPEIAE—				
	4172.1	11.8 Pt	4195.0	11.7 B
	4181.1	10.6 B		
015354 U PERSEI—				
	4167.3	9.1 Sg	4181.1	9.2 B
	4172.1	9.0 Pt	4197.3	9.7 Sg
015912 S ARIETIS—				
	4173.0	13.0 Pt	4195.1	13.9 B
021024 R ARIETIS—				
	4120.9	8.5 Kk	4180.0	11.6 Ly
	4132.9	8.5 Kk	4180.1	11.0 B
	4152.4	9.6 Mj	4181.1	11.4 Bi
	4167.5	10.6 Mj	4187.1	11.5 Ie
	4170.1	10.5 Gb	4193.1	12.0 Bi
	4173.0	10.5 Ly	4195.1	12.1 B
	4173.0	11.1 Pt	4196.1	12.2 Ly
	4173.1	11.2 Bi	4201.1	12.0 Cy
021143a W ANDROMEDAE—				
	4120.1	7.2 Kk	4143.9	7.6 Kk
	4120.9	7.2 Kk	4144.9	7.7 Kk
	4122.9	7.1 Kk	4150.9	7.9 Kk
	4123.9	7.1 Kk	4155.9	8.0 Kk
	4127.9	7.2 Kk	4162.9	8.1 Kk
	4129.9	7.2 Kk	4166.0	8.1 Kk
	4130.9	7.2 Kk	4167.0	8.5 Kk
	4132.0	7.2 Kk	4172.0	8.0 Pt
	4132.0	7.3 Kk	4174.9	8.7 Kk
	4135.9	7.4 Kk	4178.9	8.9 Kk
	4136.9	7.4 Kk	4180.1	8.7 B
	4137.9	7.5 Kk	4187.1	9.2 Ie
	4139.9	7.5 Kk	4195.1	8.8 B
	4140.9	7.6 Kk		
021258 T PERSEI—				
	4172.0	8.6 Pt		
021281 Z CEPHEI—				
	4195.2	[14.5 Wf		
021403 o CETI—				
	4120.1	5.4 Kk	4167.9	3.8 Kk
	4120.9	5.4 Kk	4169.9	3.7 Kk
	4122.9	5.3 Kk	4170.4	3.8 Kd
	4123.9	5.1 Kk	4170.5	3.7 H
	4125.4	4.6 Sm	4170.9	3.8 Kk
	4129.9	4.5 Kk	4171.2	3.9 Sg
	4130.9	4.6 Kk	4171.5	3.7 Kd
	4132.8	4.7 Kk	4171.5	3.8 H
	4135.3	4.1 Sm	4172.9	3.9 Kk
	4135.9	4.5 Kk	4173.0	3.8 Pt
	4136.9	4.4 Kk	4173.1	3.5 Jo
	4137.9	4.1 Kk	4173.4	3.9 H
	4139.9	4.2 Kk	4174.4	3.8 Kd
021403 o CETI—Continued.				
	4140.3	3.8 Sm	4174.7	3.6 L
	4142.3	3.8 Sm	4174.9	4.0 Kk
	4143.9	4.0 Kk	4175.0	3.7 H
	4144.9	3.9 Kk	4175.9	3.8 Mm
	4147.9	3.9 Kk	4175.9	4.0 Kk
	4147.9	3.8 Kd	4177.5	3.7 Kd
	4149.3	3.7 Sm	4177.9	4.0 Kk
	4149.4	4.0 Sh	4178.4	3.9 H
	4150.9	3.9 Kk	4178.5	3.5 Kd
	4152.9	3.8 Kk	4178.9	4.0 Kk
	4153.5	3.7 Kd	4179.5	4.0 H
	4154.4	3.6 Kd	4180.0	3.9 Ly
	4158.7	3.3 L	4181.0	3.6 Cy
	4158.9	3.9 Kk	4181.9	4.0 Kk
	4159.4	3.7 Kd	4182.4	4.3 H
	4160.9	4.0 Kk	4195.0	4.5 Ly
	4161.4	3.7 Kd	4196.0	4.4 Ly
	4162.9	3.8 Kk	4197.0	4.8 Ly
	4164.4	3.8 Kd	4199.0	4.7 Ly
	4166.0	3.8 Kk	4201.0	4.5 Ly
	4167.4	3.7 Kd		
021558 S PERSEI—				
	4133	10.2 Kl	4181.1	10.1 B
	4173.0	10.4 Pt	4196.0	10.8 Pt
022150 RR PERSEI—				
	4195.1	13.8 B	4195.2	14.6 Wf
022426 R FORNACIS—				
	4121.0	9.0 Bl	4137.0	9.3 Bl
	4129.1	9.0 Bl	4144.0	9.8 Bl
022813 U CETI—				
	4173.0	11.1 Pt		
022980 RR CEPHEI—				
	4195.2	14.1 Wf		
023133 R TRIANGULI—				
	4147.9	6.8 Kd	4187.1	8.5 Ie
	4170.0	7.9 Kk	4187.6	7.6 Bi
	4173.0	6.8 Pt	4196.1	8.3 Lv
	4173.1	6.8 Bi	4201.1	8.6 Cy
	4174.9	8.0 Kk		
024356 W PERSEI—				
	4152.4	9.2 Mj	4181.2	8.4 B
	4166.6	9.2 Cy	4196.1	8.9 Cy
	4167.5	9.3 Mj	4201.1	8.9 Cy
	4173.0	8.9 Pt		
025050 R HOROLOGII—				
	4121.0	7.3 Bl	4139.4	8.4 Sm
	4125.3	8.1 Sm	4144.0	9.7 Bl
	4129.1	8.2 Bl	4150.3	9.0 Sm
	4137.0	8.0 Bl		
025751 T HOROLOGII—				
	4121.0	9.3 Bl	4140.4	8.3 Sm
	4125.3	8.3 Sm	4144.0	9.2 Bl
	4129.1	8.1 Bl	4150.4	8.6 Sm
	4137.1	8.6 Bl		
030514 U ARIETIS—				
	4194.1	13.4 B	4197.0	13.0 Y
031401 X CETI—				
	4158.7	8.9 L	4173.0	8.4 Pt

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
032043 Y PERSEI—				
	4173.0	10.2 Pt		
032335 R PERSEI—				
	4173.0	9.3 Pt	4194.2	10.3 B
	4182.1	9.7 Ie		
042215 W TAURI—				
	4152.5	10.2 Mj	4194.2	11.7 B
	4167.5	10.7 Mj	4195.1	11.1 Cy
	4173.0	10.8 Pt	4201.1	11.8 Cy
043065 T CAMELOPARDALIS—				
	4173.0	12.0 Pt		
043208 RX TAURI—				
	4173.1	11.9 Bi	4195.2	10.9 Lv
	4187.1	10.6 Bi	4195.2	10.7 B
043263 R RETICULI—				
	4121.0	8.7 Bl	4137.1	7.4 Bl
	4124.4	8.1 Sm	4142.3	7.1 Sm
	4129.1	8.0 Bl	4144.0	7.1 Bl
	4136.3	7.4 Sm	4150.3	7.2 Sm
043274 X CAMELOPARDALIS—				
	4173.0	11.8 Pt	4181.1	11.2 B
043562 R DORADUS—				
	4121.0	5.8 Bl	4137.1	5.8 Bl
	4124.4	5.8 Sm	4142.3	5.8 Sm
	4129.1	5.8 Bl	4144.0	5.6 Bl
	4136.3	6.0 Sm	4150.3	5.8 Sm
043738 R CAELI—				
	4137.1	12.2 Bl	4144.0	12.1 Bl
044349 R PICTORIS—				
	4121.0	7.8 Bl	4141.2	9.1 Bl
	4129.1	8.4 Bl	4144.0	9.2 Bl
	4137.1	9.1 Bl		
044617 V TAURI—				
	4173.0	12.6 Pt	4194.1	10.4 B
	4174.1	12.6 Ie		
045307 R ORIONIS—				
	4195.2	12.4 B	4201.1	11.6 Y
045514 R LEPORIS—				
	4120.1	8.3 Kk	4173.0	7.1 Ly
	4124.1	8.2 Kk	4173.0	6.5 Pt
	4127.1	8.0 Kk	4174.7	7.0 L
	4135.1	7.7 Kk	4174.9	7.4 Kk
	4138.0	7.7 Kk	4175.9	7.5 Kk
	4150.9	7.6 Kk	4177.9	7.5 Kk
	4153.8	7.6 Kk	4178.9	7.4 Kk
	4158.9	7.6 Kk	4180.0	7.6 Ly
	4158.9	6.5 L	4181.0	7.4 Kk
	4161.9	7.6 Kk	4181.9	7.4 Kk
	4166.0	7.5 Kk	4184.1	7.0 Jo
	4168.9	7.0 L	4195.1	6.7 Jo
	4170.0	7.5 Kk	4197.0	7.5 Ly
	4171.8	6.9 Mm	4201.0	7.5 Ly
	4172.9	7.6 Kk	4202.0	7.0 Ho
050003 V ORIONIS—				
	4175.2	10.4 Br	4194.2	10.9 B
	4175.1	10.0 Pt	4201.1	11.3 Y
	4182.1	10.6 Ie		
050022 T LEPORIS—				
	4121.0	10.2 Bl	4144.0	8.8 Bl
	4129.1	9.1 Bl	4173.1	9.0 Pt
	4137.1	8.9 Bl	4181.1	8.2 B
050848 S PICTORIS—				
	4121.0	12.5 Bl	4140.3	11.8 Sm
	4129.1	11.7 Bl	4144.0	11.3 Bl
	4135.3	12.2 Sm	4149.3	11.4 Sm
	4137.1	11.4 Bl		
050953 R AURIGAE—				
	4166.2	12.1 Br	4187.1	10.9 Ie
	4173.1	11.9 Pt	4193.3	11.2 Lv
	4173.1	11.2 Bi		
051247 T PICTORIS—				
	4122.3	[11.8 Sm	4137.1	[13.1 Bl
	4135.3	[11.8 Sm		
051533 T COLUMBAE—				
	4121.0	7.9 Bl	4137.1	7.9 Bl
	4124.3	7.6 Sm	4142.2	7.9 Sm
	4129.1	7.6 Bl	4144.0	8.3 Bl
	4136.3	7.8 Sm	4149.3	8.3 Sm
052034 S AURIGAE—				
	4173.1	8.5 Pt	4197.3	9.8 Sg
052036 W AURIGAE—				
	4173.1	14.6 Pt		
052404 S ORIONIS—				
	4173.1	7.9 Pt	4181.1	8.5 B
	4175.2	8.1 Br	4196.0	8.7 Pt
053005a. T. ORIONIS—				
	4147.7	10.9 L	4182.0	10.1 Pt
	4167.5	11.0 Mj	4187.2	10.2 Pt
	4170.9	10.3 Kk	4188.0	10.1 Pt
	4172.2	10.0 Pt	4189.0	10.2 Pt
	4173.0	10.6 Kk	4190.0	10.1 Pt
	4173.1	10.0 Pt	4194.2	11.1 B
	4176.0	10.3 Kk	4196.0	10.2 Pt
	4179.1	10.0 Pt	4198.0	10.3 Pt
	4180.1	11.0 B	4200.0	10.4 Pt
053068 S CAMELOPARDALIS—				
	4173.1	10.2 Pt		
053337 RU AURIGAE—				
	4175.2	[13.4 Br	4197.3	[11.6 Sg
	4196.0	[13.4 Pt		
053531 U AURIGAE—				
	4173.1	12.5 Pt	4182.0	12.9 B
	4175.2	12.9 Br		
053920 Y TAURI—				
	4114.3	8.7 Au	4143.4	8.1 Au
	4114.3	8.7 Au	4143.4	7.9 Au
	4116.3	8.1 Au	4153.8	8.0 Au
	4116.4	8.0 Au	4163.8	7.9 Au
	4117.3	8.1 Au	4163.8	7.9 Au
	4117.3	8.4 Au	4164.8	8.0 Au
	4137.3	8.1 Au	4164.8	8.0 Au
	4137.3	7.8 Au	4166.8	8.0 Au
	4138.3	7.9 Au	4166.8	8.0 Au
	4138.3	8.2 Au		

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
054319 SU TAURI—				
	4164.3	10.8 Wf	4182.1	10.0 Ie
	4166.1	10.9 Br	4187.2	10.1 Pt
	4172.2	10.6 Pt	4188.0	10.2 Pt
	4173.0	10.4 Ie	4189.0	10.2 Pt
	4173.1	10.7 Pt	4190.0	10.2 Pt
	4173.1	10.4 Bi	4193.1	10.1 Bi
	4174.8	10.7 L	4195.1	10.7 Br
	4175.1	10.4 Wf	4195.2	10.0 Lv
	4175.1	10.5 Br	4196.0	10.3 Pt
	4179.1	10.5 Pt	4198.0	10.2 Pt
	4181.1	10.0 Pt	4200.0	10.2 Pt
	4182.0	10.6 Pt	4201.0	10.2 Pt
054331 S COLUMBAE—				
	4137.1	[13.1 Bl	4142.3	[12.6 Sm
054615a Z TAURI—				
	4174.1	12.9 Ie	4175.2	12.6 Br
054615c RU TAURI—				
	4174.1	12.9 Ie	4175.2	13.2 Br
054629 R COLUMBAE—				
	4122.3	[12.0 Sm	4137.1	[13.0 Bl
	4136.3	[12.4 Sm	4142.3	[12.4 Sm
054920a U ORIONIS—				
	4124.1	8.8 Kk	4173.1	10.0 Pt
	4170.1	9.7 Gb	4193.1	10.3 Bi
	4171.2	10.0 Sg	4193.1	10.9 Lv
	4171.8	9.4 Mm	4196.1	10.7 Cy
	4173.2	9.5 Bi		
054920b UW ORIONIS—				
	4173.2	10.4 Bi	4196.1	10.2 Cy
	4193.1	10.6 Bi	4201.1	10.5 Cy
	4193.1	10.8 Lv		
054974 V CAMELOPARDALIS—				
	4173.1	13.6 Pt	4197.1	[12.6 Y
	4175.2	13.5 Br		
055353 Z AURIGAE—				
	4167.5	10.7 Mj	4196.0	10.8 Pt
	4173.1	10.6 Pt	4200.0	11.0 Pt
	4182.0	10.5 B		
055686 R OCTANTIS—				
	4121.0	9.8 Bl	4137.1	8.6 Bl
	4122.3	9.6 Sm	4149.3	7.8 Sm
	4129.1	9.5 Bl	4144.0	8.2 Bl
	4139.3	8.6 Sm		
060450 X AURIGAE—				
	4113.1	12.2 Pt	4178.0	12.7 B
060547 SS AURIGAE—				
	4158.7	[12.4 L	4180.0	[13.3 Ie
	4164.2	[14.5 Wf	4181.1	[12.4 Pt
	4166.1	[13.9 Br	4182.0	[12.6 Pt
	4168.9	[13.9 L	4187.0	[12.6 Ie
	4170.2	[13.9 L	4188.0	[12.6 Pt
	4171.8	[12.6 Mm	4189.0	[11.0 Pt
	4172.2	[12.6 Pt	4191.2	[12.4 Wf
	4173.1	[14.0 Bi	4193.1	[14.0 Lv
	4174.0	[13.9 Ie	4195.2	15.1 Wf
	4174.8	[14.5 L	4196.0	[12.6 Pt
	4175.1	15.3 Wf	4197.0	[13.4 Cd
	4176.1	[14.5 Wf	4198.0	[12.6 Pt
060547 SS AURIGAE—Continued.				
	4178.1	[14.0 B	4200.0	[12.6 Pt
	4179.1	[12.6 Pt	4201.2	[13.0 Cy
061647 V AURIGAE—				
	4178.0	10.8 B		
061702 V MONOCEROTIS—				
	4173.1	7.9 Pt	4195.2	6.9 Br
063159 U LYNCIS—				
	4197.1	10.9 Y		
063308 R MONOCEROTIS—				
	4173.1	10.4 Pt	4178.1	11.6 B
063558 S LYNCIS—				
	4173.1	8.9 Pt	4195.2	9.5 Br
	4182.1	9.0 B		
064030 X GEMINORUM—				
	4170.1	11.0 B	4195.2	9.3 Br
064707 W MONOCEROTIS—				
	4173.1	10.1 Pt	4195.2	10.3 Br
	4178.1	9.6 B		
065111 Y MONOCEROTIS—				
	4173.2	12.6 Bi	4193.1	11.1 Lv
	4185.1	11.5 Bi	4201.1	10.6 Y
065208 X MONOCEROTIS—				
	4163.3	8.9 Au	4166.8	9.0 Au
	4164.8	8.7 Au	4168.9	8.5 L
	4166.8	8.8 Au		
065355 R LYNCIS—				
	4197.1	[13.5 Y		
070109 V CANIS MINORIS—				
	4169.1	13.3 B		
070122a R GEMINORUM—				
	4120.1	7.1 Kk	4166.0	8.2 Kk
	4120.9	7.1 Kk	4170.9	8.2 Kk
	4123.0	7.0 Kk	4171.2	8.5 Sg
	4124.1	7.2 Kk	4173.2	8.1 Bi
	4128.1	7.0 Kk	4174.9	8.3 Kk
	4130.1	7.0 Kk	4175.2	8.1 Al
	4131.1	7.0 Kk	4178.9	8.4 Kk
	4132.3	7.0 Kk	4179.1	8.6 Pt
	4135.1	7.2 Kk	4180.1	8.7 B
	4137.0	7.3 Kk	4182.1	8.6 Ie
	4138.0	7.5 Kk	4182.2	8.8 Al
	4141.0	7.7 Kk	4185.1	8.4 Bi
	4143.9	7.7 Kk	4193.2	8.8 Bi
	4150.9	7.9 Kk	4194.1	9.4 B
	4162.9	8.2 Kk	4196.2	9.0 Al
070122b Z GEMINORUM—				
	4173.2	8.1 Bi	4185.1	8.3 Bi
	4179.1	7.9 Pt	4193.2	8.3 Bi
	4180.1	8.0 B	4194.1	7.8 B
070310 R CANIS MINORIS—				
	4147.4	8.5 Sh	4168.9	8.5 L
	4149.4	8.6 Sh	4180.1	8.9 B
	4151.5	8.7 Sh		
070772 R VOLANTIS—				
	4122.3	9.6 Sm	4142.3	9.9 Sm
	4136.3	9.8 Sm	4149.4	9.9 Sm
071201 RR MONOCEROTIS—				
	4173.2	11.9 Bi	4193.2	13.0 Bi
	4185.1	12.4 Bi	4193.1	12.8 Lv

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
071713 V GEMINORUM—				
	4179.1	13.7 Pt		
072708 S CANIS MINORIS—				
	4168.9	8.6 L	4182.2	9.5 Wr
	4169.1	9.1 B	4187.1	8.7 Ie
	4171.8	9.0 Mm	4195.2	8.6 Cy
	4175.1	9.0 Al	4196.1	8.2 Jo
	4179.1	8.9 Pt	4196.2	9.0 Al
	4180.0	8.7 Cd	4199.0	8.5 Cd
072811 T CANIS MINORIS—				
	4168.1	13.3 B		
072820b Z VOLANTIS—				
	4195.2	13.0 Br		
073173 S VOLANTIS—				
	4121.6	10.5 Bl	4137.1	10.3 Bl
	4129.1	10.7 Bl	4144.1	10.5 Bl
073508 U CANIS MINORIS—				
	4168.9	8.4 L	4179.1	8.8 Pt
	4168.1	8.8 B	4201.1	9.0 Y
073723 S GEMINORUM—				
	4169.1	13.3 B	4194.1	12.1 B
	4179.1	12.7 Pt		
074241 W PUPPIS—				
	4121.0	9.1 Bl	4137.1	8.8 Bl
	4122.3	8.9 Sm	4142.0	9.0 Sm
	4129.1	8.7 Bl	4144.0	9.0 Bl
	4136.3	8.7 Sm	4149.4	9.7 Sm
074323 T GEMINORUM—				
	4174.1	11.4 Ie	4196.0	10.0 Pt
	4182.1	10.9 B		
074922 U GEMINORUM—				
	4164.3	10.2 Wf	4181.1	[12.4 Pt
	4166.1	11.6 Br	4182.1	[13.5 B
	4168.1	13.2 B	4187.2	[11.3 Pt
	4169.1	13.6 B	4188.0	[10.9 Pt
	4171.2	[13.4 L	4190.0	[9.3 Pt
	4172.2	[13.3 Pt	4191.2	[12.4 Wf
	4173.2	13.8 Bi	4193.1	[13.8 Lv
	4174.1	13.9 Ie	4194.1	14.0 B
	4174.8	13.5 L	4195.2	13.8 Wf
	4175.1	13.7 Wf	4196.1	[13.3 Pt
	4175.2	13.8 Br	4197.0	13.8 Cd
	4176.2	[13.7 Wf	4198.0	[12.4 Pt
	4178.1	[13.3 Pt	4200.0	[13.7 Pt
	4179.1	[13.3 Pt	4201.2	[13.3 Cy
	4180.1	[13.8 B		
075612 U PUPPIS—				
	4201.1	12.5 Y		
081112 R CANCRI—				
	4168.2	9.5 B	4187.1	9.0 Ie
	4174.8	9.7 L	4179.1	9.4 Pt
	4175.9	9.7 Mm	4194.1	9.1 Cy
	4179.1	9.4 Pt	4196.2	8.8 Cy
081617 V CANCRI—				
	4179.1	8.5 Pt	4196.2	9.0 Cy
	4182.1	8.5 B		
082405 RT HYDRAE—				
	4179.1	7.6 Pt	4194.1	7.5 B
	4180.1	7.7 B		
082476 R CHAMAELEONTIS—				
	4141.2	[12.6 Bl		
083019 U CANCRI—				
	4173.2	10.4 Bi	4196.2	10.8 Cy
083350 X URSAE MAJORIS—				
	4173.2	[13.6 Bi		
084309 RV HYDRAE—				
	4152.0	8.2 Sh		
084803 S HYDRAE—				
	4179.1	7.3 Pt	4196.2	7.4 Cy
	4180.1	7.3 B		
085008 T HYDRAE—				
	4174.9	11.5 L	4182.1	12.1 B
	4179.1	12.0 Pt	4201.2	12.4 Cy
085120 T CANCRI—				
	4179.1	7.7 Pt	4196.2	8.4 Cy
	4180.1	8.4 B		
090024 S PYXIDIS—				
	4178.1	7.9 Pt		
090151 V URSAE MAJORIS—				
	4182.1	10.7 B		
090425 W CANCRI—				
	4195.1	9.0 B	4196.2	9.3 Cy
091868 RW CARINAE—				
	4141.2	[12.8 Bl		
092551 Y VELORUM—				
	4141.2	[12.9 Bl		
092962 R CARINAE—				
	4121.0	4.2 Bl	4137.1	5.2 Bl
	4122.4	4.9 Sm	4142.4	5.4 Sm
	4129.1	4.9 Bl	4144.0	5.2 Bl
	4136.3	4.9 Sm	4149.4	5.8 Sm
093014 X HYDRAE—				
	4179.1	10.9 Pt	4201.2	10.0 Cy
	4195.1	10.0 B		
093178 Y DRACONIS—				
	4197.1	[13.4 Y		
093934 R LEONIS MINORIS—				
	4179.1	11.1 Pt	4196.3	11.3 Cy
	4182.2	10.5 Al		
094211 R LEONIS—				
	4170.1	9.8 Kk	4196.1	8.9 Al
	4175.1	9.7 Kk	4196.2	8.3 Jo
	4175.2	9.0 Al	4196.3	9.4 Cy
	4179.1	8.6 Pt	4197.3	8.9 Sg
	4182.0	9.6 Kk	4198.1	9.5 Mh
	4182.1	8.8 B	4201.0	9.6 Ly
	4182.2	9.3 Al	4202.0	8.0 Ho
	4185.2	8.5 Jo		
094622 Y HYDRAE—				
	4179.1	6.7 Pt		
094953 Z VELORUM—				
	4121.0	8.8 Bl	4141.2	7.9 Bl
	4124.4	8.2 Sm	4142.4	7.9 Sm
	4129.1	8.1 Bl	4144.0	7.9 Bl
	4136.4	7.9 Sm	4149.4	7.9 Sm
	4137.1	7.9 Bl		
095421 V LEONIS—				
	4173.3	11.5 Bi	4182.1	11.9 B
	4179.1	11.2 Pt	4196.3	12.2 Cy

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
095563 RV CARINAE—						
	4141.2	[13.1	Bl			
095814 RY LEONIS—						
	4195.8	9.4	Kl			
100661 S CARINAE—						
	4121.1	7.1	Bl			
101058 Z CARINAE—						
	4121.1	12.4	Bl	4141.2	13.0	Bl
101153 W VELORUM—						
	4121.1	9.4	Bl	4137.1	9.5	Bl
	4129.1	9.7	Bl	4144.0	9.8	Bl
103212 U HYDRAE—						
	4120.3	5.6	Kk	4156.9	6.1	Kd
	4121.3	5.7	Kk	4168.3	5.8	Kk
	4122.3	5.7	Kk	4170.3	5.8	Kk
	4123.3	5.7	Kk	4170.9	5.8	Kd
	4124.3	5.6	Kk	4171.4	5.8	Kk
	4133.3	6.4	Kk	4172.3	6.0	Kk
	4140.4	5.5	Kk	4173.3	5.8	Kk
	4141.3	5.8	Kk	4175.4	5.8	Kk
	4147.3	6.1	Kd	4176.3	6.0	Kk
	4147.3	5.7	Kk	4177.9	5.7	Kd
	4152.3	5.8	Kk	4182.4	5.5	Kk
	4153.2	5.8	Kk			
103769 R URSAE MAJORIS—						
	4153.3	7.0	Kk	4179.1	7.2	Pt
	4158.3	7.0	Kk	4180.0	7.4	Ly
	4162.3	7.0	Kk	4181.1	7.6	Kk
	4166.0	7.0	Kk	4181.2	7.6	H
	4167.9	7.0	Kk	4181.9	7.6	Kk
	4168.3	7.3	Kk	4182.2	7.5	Du
	4170.0	7.3	Kk	4182.2	7.4	Al
	4170.9	7.5	Kk	4182.4	7.6	H
	4172.1	7.5	Kk	4189.2	8.4	Mh
	4172.9	7.5	Kk	4195.0	7.8	Ly
	4173.0	7.0	Ly	4196.2	7.7	Al
	4173.2	7.5	Bi	4196.2	7.8	Du
	4174.1	7.0	Ie	4197.0	8.2	Ly
	4174.2	7.4	Du	4198.1	8.7	Mh
	4174.3	7.5	Kk	4199.0	8.2	Ly
	4176.4	7.6	Kk	4201.2	8.3	Cy
	4178.9	7.6	Kk			
104620 V HYDRAE—						
	4121.2	10.3	Bl	4141.2	10.7	Bl
	4129.1	10.3	Bl	4144.4	11.1	Bl
	4137.1	10.2	Bl	4181.4	11.8	Pt
104628 RS HYDRAE—						
	4121.2	13.5	Bl	4141.2	13.7	Bl
104814 W LEONIS—						
	4173.3	13.3	Bi	4201.1	12.9	Y
110361 RS CARINAE—						
	4136.4	[12.6	Sm	4150.3	[12.1	Sm
111561 RY CARINAE—						
	4121.1	[13.1	Bl	4141.2	[13.5	Bl
111661 R CENTAURI—						
	4121.1	12.7	Bl	4144.0	12.6	Bl
	4141.2	12.9	Bl			
114441 X CENTAURI—						
	4121.2	10.7	Bl	4137.1	11.0	Bl
	4129.1	11.0	Bl	4144.0	11.3	Bl
115058 W CENTAURI—						
	4121.1	12.4	Bl	4141.2	13.5	Bl
115919 R COMAE—						
	4173.3	[13.5	Bi	4201.0	[12.5	Cd
120012 SU VIRGINIS—						
	4181.4	11.3	Pt			
120905 T VIRGINIS—						
	4181.4	13.9	Pt			
121418 R CORVI—						
	4170.2	10.9	L	4181.4	11.2	Pt
122001 SS VIRGINIS—						
	4147.3	7.6	Kd	4170.2	7.0	L
	4156.9	7.7	Kd	4177.9	7.8	Kd
122532 T CANUM VENATICORUM—						
	4181.4	9.6	Pt	4196.1	10.0	Al
122803 Y VIRGINIS—						
	4171.2	10.7	L			
122854 U CENTAURI—						
	4129.0	8.8	Bl	4142 1	8.5	Bl
	4137.1	9.2	Bl	4144.0	10.1	Bl
123160 T URSAE MAJORIS—						
	4127.0	10.3	Kl	4173.3	11.8	Bi
	4133.0	10.6	Kl	4175.2	11.0	Al
	4143.0	9.8	Kl	4181.4	12.4	Pt
	4146.0	10.1	Kl	4201.2	[12.4	Cy
	4170.8	10.7	Kl			
123307 R VIRGINIS—						
	4171.2	11.2	L	4181.4	10.5	Pt
123459 RS URSAE MAJORIS—						
	4173.3	13.2	Bi	4197.3	12.0	Sg
	4181.4	13.0	Pt	4201.2	11.5	Cy
	4197.0	12.0	Cd			
123961 S URSAE MAJORIS—						
	4127.0	9.0	Kl	4195.8	10.2	Kl
	4133.0	10.5	Kl	4196.2	10.0	Al
	4143.0	11.3	Kl	4197.1	10.3	Cd
	4170.7	11.3	Kl	4197.3	9.9	Sg
	4171.2	11.6	L	4198.1	9.5	Mh
	4181.4	10.8	Pt	4201.2	9.5	Ly
	4182.2	11.0	Al	4201.2	9.5	Cy
	4195.0	11.0	Ly	4201.2	9.5	Du
	4195.1	9.5	Jo			
124204 RU VIRGINIS—						
	4181.4	12.6	Pt			
124606 U VIRGINIS—						
	4181.4	11.6	Pt			
131283 U OCTANTIS—						
	4121.1	12.5	Bl	4141.2	13.5	Bl
	4139.3	12.9	Sm			
132422 R HYDRAE—						
	4141.2	8.8	Bl	4170.9	8.3	Kd
	4147.3	9.0	Kd	4177.8	8.2	Kd
	4170.2	7.6	L	4181.4	7.8	Pt
132706 S VIRGINIS—						
	4181.4	11.0	Pt			
133155 RV CENTAURI—						
	4121.2	7.8	Bl	4137.1	8.2	Bl
	4129.1	8.0	Bl	4144.1	8.1	Bl
133273 T URSAE MINORIS—						
	4197.2	9.3	Jo			

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
133633 T CENTAURI—				
	4141.2	5.9 Bl	4170.9	6.8 Kd
	4147.3	6.2 Kd	4172.9	7.0 Kd
	4148.4	6.1 Kd	4177.9	7.6 Kd
	4163.9	6.3 Kd		
134236 RT CENTAURI—				
	4141.2	12.5 Bl		
134440 R CANUM VENATICORUM—				
	4181.4	8.2 Pt		
134536 RX CENTAURI—				
	4141.2	12.5 Bl		
134677 T APODIS—				
	4121.1	9.2 Bl	4137.1	8.9 Bl
	4122.3	9.0 Sm	4144.1	9.4 Bl
	4129.1	8.7 Bl	4142.1	9.2 Sm
	4136.3	9.0 Sm	4150.4	9.4 Sm
135908 RR VIRGINIS—				
	4181.4	13.1 Pt		
140512 Z VIRGINIS—				
	4181.4	10.8 Pt		
140528 RU HYDRAE—				
	4141.2	[12.9 Bl		
140959 R CENTAURI—				
	4121.2	7.5 Bl	4137.1	7.8 Bl
	4129.1	7.6 Bl	4144.1	8.1 Bl
141567 U URSAE MINORIS—				
	4181.4	8.0 Pt		
141954 S BOOTIS—				
	4175.2	11.8 L	4181.4	12.2 Pt
142539 V BOOTIS—				
	4140.3	8.2 Kk	4171.3	8.0 Kk
	4141.3	8.2 Kk	4172.3	8.2 Kk
	4147.3	8.2 Kk	4173.3	8.0 Kk
	4148.3	8.0 Kk	4174.4	8.0 Kk
	4153.2	8.0 Kk	4175.2	7.8 L
	4158.3	8.0 Kk	4175.4	8.1 Kk
	4162.3	7.9 Kk	4176.4	8.1 Kk
	4165.3	7.9 Kk	4181.4	7.9 Pt
	4168.3	7.9 Kk	4182.3	8.4 Kk
	4170.3	8.0 Kk	4201.4	7.5 Al
143227 R BOOTIS—				
	4140.3	8.3 Kk	4171.4	7.9 Kk
	4141.3	8.2 Kk	4172.4	8.0 Kk
	4147.3	8.1 Kk	4173.3	8.1 Kk
	4148.3	8.2 Kk	4174.4	8.0 Kk
	4153.2	8.1 Kk	4176.4	8.0 Kk
	4165.4	8.1 Kk	4181.4	8.0 Pt
	4168.4	8.0 Kk	4182.3	8.3 Kk
	4170.4	8.1 Kk		
145254 Y LUPI—				
	4141.2	[12.8 Bl		
145971 S APODIS—				
	4121.1	10.1 Bl	4141.2	10.4 Bl
	4129.1	10.0 Bl	4144.1	10.3 Bl
	4137.1	10.3 Bl		
150018 RT LIBRAE—				
	4181.4	12.1 Pt		
150605 Y LIBRAE—				
	4171.2	9.2 L	4181.4	9.1 Pt
151520 S LIBRAE—				
	4170.2	9.0 L		
151714 S SERPENTIS—				
	4175.2	12.4 L	4181.4	12.5 Pt
151731 S CORONAE BOREALIS—				
	4127.3	7.3 Kk	4153.3	7.4 Kk
	4132.4	7.1 Kk	4163.3	7.9 Kk
	4133.3	7.2 Kk	4168.3	8.1 Kk
	4134.3	7.1 Kk	4170.4	8.1 Kk
	4137.3	7.0 Kk	4172.3	8.3 Kk
	4140.3	7.0 Kk	4176.4	8.4 Kk
	4141.3	7.0 Kk	4181.4	7.7 Pt
	4147.3	7.2 Kk	4182.4	8.7 Kk
	4148.3	7.2 Kk	4183.2	8.0 Gb
	4152.3	7.3 Kk	4196.4	8.5 Cd
151822 RS LIBRAE—				
	4141.2	10.2 Bl	4171.2	11.9 L
152714 RY LIBRAE—				
	4170.2	8.5 L	4181.4	8.6 Pt
152849 R NORMAE—				
	4141.2	[11.9 Bl		
153378 S URSAE MINORIS—				
	4181.4	9.0 Pt	4201.2	9.8 Du
	4201.2	9.4 Cy		
154428 R CORONAE BOREALIS—				
	4120.3	6.4 Kk	4164.4	5.9 Kk
	4121.3	6.3 Kk	4165.4	6.0 Kk
	4122.3	6.4 Kk	4168.3	5.9 Kk
	4123.3	6.4 Kk	4170.3	6.0 Kk
	4124.3	6.4 Kk	4170.4	6.2 Kd
	4127.3	6.4 Kk	4171.3	5.9 Kk
	4128.3	6.4 Kk	4172.4	6.2 Pt
	4130.3	6.3 Kk	4172.4	5.9 Kk
	4132.4	6.3 Kk	4173.3	6.0 Kk
	4133.3	6.3 Kk	4173.4	6.2 Pt
	4134.3	6.2 Kk	4174.3	6.1 Kk
	4137.3	6.2 Kk	4175.3	6.1 Kk
	4138.3	6.2 Kk	4176.4	5.9 Kk
	4140.3	6.1 Kk	4177.4	6.2 Kd
	4141.3	6.0 Kk	4179.3	5.9 Kk
	4144.3	6.0 Kk	4181.4	5.9 Kk
	4147.3	5.9 Kk	4181.4	6.1 Pt
	4147.3	6.2 Kd	4182.3	5.8 Kk
	4148.3	5.9 Kk	4182.4	6.1 Pt
	4148.4	6.2 Kd	4183.2	6.3 Gb
	4152.3	6.0 Kk	4190.3	6.1 Pt
	4153.3	6.0 Kk	4196.4	6.1 Pt
	4154.3	6.3 Kd	4196.4	6.0 Cd
	4155.3	5.9 Kk	4198.3	6.1 Pt
	4156.4	6.3 Kd	4200.4	6.1 Pt
	4160.3	6.0 Kk	4201.2	6.2 Cy
	4160.4	5.9 Kk	4201.4	6.4 Al
	4163.4	6.2 Kd	4201.4	6.1 Pt
154536 X CORONAE BOREALIS—				
	4181.4	9.3 Pt		
154615 R SERPENTIS—				
	4182.4	6.8 Pt		
154639 V CORONAE BOREALIS—				
	4181.4	8.0 Pt		

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
155018 RR LIBRAE—						
	4171.2	11.8	L	4182.4	13.3	Pt
155823 RZ SCORPII—						
	4182.4	12.1	Pt			
160021 Z SCORPII—						
	4170.2	10.6	L			
160118 R HERCULIS—						
	4182.4	9.8	Pt			
160210 U SERPENTIS—						
	4182.4	11.1	Pt			
160325 SX HERCULIS—						
	4173.4	8.0	Pt	4196.4	8.8	Pt
	4181.4	8.5	Pt	4198.4	8.7	Pt
	4182.4	8.5	Pt	4200.4	8.9	Pt
	4189.3	8.7	Pt	4201.4	8.9	Pt
160625 RU HERCULIS—						
	4182.4	14.1	Pt			
161122b S SCORPII—						
	4182.4	13.0	Pt			
161138 W CORONAE BOREALIS—						
	4182.4	9.2	Pt			
161607 W OPHIUCHI—						
	4171.2	10.9	L	4182.4	11.7	Pt
162112 V OPHIUCHI—						
	4182.4	7.5	Pt			
162119 U HERCULIS—						
	4182.4	12.2	Pt			
162807 SS HERCULIS—						
	4175.2	8.5	L	4182.4	8.8	Pt
162815 T OPHIUCHI—						
	4175.2	12.8	L			
162816 S OPHIUCHI—						
	4175.2	[13.7	L			
163137 W HERCULIS—						
	4182.4	14.0	Pt			
163266 R DRACONIS—						
	4182.4	9.0	Pt			
164319 RR OPHIUCHI—						
	4171.2	9.3	L	4182.4	9.1	Pt
164715 S HERCULIS—						
	4182.4	12.0	Pt			
165202 SS OPHIUCHI—						
	4182.4	8.9	Pt			
165631 RV HERCULIS—						
	4182.4	12.0	Pt			
171401 Z OPHIUCHI—						
	4182.4	8.6	Pt			
171723 RS HERCULIS—						
	4182.4	12.2	Pt			
172486 S OCTANTIS—						
	4121.0	11.2	Bl	4137.0	9.6	Bl
	4129.1	9.9	Bl	4144.1	9.5	Bl
172809 RU OPHIUCHI—						
	4182.4	13.0	Pt			
173543 RU SCORPII—						
	4120.9	9.4	Bl	4127.0	9.5	Bl
174162 W PAVONIS—						
	4137.0	[12.3	Bl			
174406 RS OPHIUCHI—						
	4182.4	11.1	Pt			
175519 RY HERCULIS—						
	4182.4	8.8	Pt			
175654 V DRACONIS—						
	4182.4	10.6	Pt			
180363 R PAVONIS—						
	4122.3	11.0	Sm			
180531 T HERCULIS—						
	4182.4	8.5	Kk	4182.4	8.0	Pt
180565 W DRACONIS—						
	4182.4	10.5	Pt			
181136 W LYRAE—						
	4182.4	9.1	Pt			
182133 RV SAGITTARII—						
	4120.9	12.1	Bl			
182306 T SERPENTIS—						
	4182.4	10.0	Pt			
183308 X OPHIUCHI—						
	4175.2	6.5	L	4182.4	6.8	Pt
184134 RY LYRAE—						
	4182.4	10.8	Pt			
184205 R SCUTI—						
	4120.9	5.9	Kk	4170.2	6.3	L
	4121.9	5.9	Kk	4170.4	6.4	Kd
	4122.9	5.9	Kk	4177.4	6.4	Kd
	4123.9	5.9	Kk	4182.4	6.0	Kk
	4127.9	6.0	Kk	4182.4	6.0	Pt
	4129.9	6.0	Kk	4196.4	5.1	Pt
	4130.9	6.0	Kk	4200.4	5.0	Pt
	4132.9	6.2	Kk	4201.4	4.9	Pt
184300 NOVA AQUILAE #3—						
	4182.4	10.6	Pt	4196.4	10.6	Pt
185437a S CORONAE BOREALIS—						
	4121.0	12.0	Bl			
185634 Z LYRAE—						
	4182.4	9.4	Pt			
190108 R AQUILAE—						
	4182.4	6.5	Pt			
190926 X LYRAE—						
	4182.4	9.0	Pt			
190933a RS LYRAE—						
	4182.4	13.5	Pt			
190941 RU LYRAE—						
	4182.4	12.2	Pt			
190967a U DRACONIS—						
	4182.4	13.5	Pt			
191033 RY SAGITTARII—						
	4121.0	7.6	Bl	4137.0	7.7	Bl
	4127.0	7.5	Bl	4144.0	7.7	Bl
191124 TY SAGITTARII—						
	4121.0	9.9	Bl			
191319 S SAGITTARII—						
	4121.0	[11.1	Bl			
191331 SW SAGITTARII—						
	4121.0	11.8	Bl			
191350 TZ CYGNI—						
	4182.4	11.1	Pt			
191637 U LYRAE—						
	4182.4	13.5	Pt			
192928 TY CYGNI—						
	4182.4	13.5	Pt			

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.	Obs.	J.D.	Est.	Obs.
193311	RT AQUILAE—					
	4182.4	11.9	Pt			
193449	R CYGNI—					
	4172.0	10.8	Pt			
193972	T PAVONIS—					
	4121.0	12.6	Bl	4137.0	13.4	Bl
194048	RT CYGNI—					
	4172.0	10.6	Pt			
194348	TU CYGNI—					
	4172.0	11.1	Pt			
194632	χ CYGNI—					
	4120.9	6.1	Kk	4154.4	5.9	Kd
	4122.9	6.1	Kk	4155.9	6.4	Kk
	4123.9	6.2	Kk	4159.4	5.9	Kd
	4127.9	6.1	Kk	4162.9	6.6	Kk
	4129.9	6.1	Kk	4163.4	6.0	Kd
	4130.9	5.9	Kk	4164.4	6.0	Kd
	4132.9	6.1	Kk	4167.4	6.1	Kd
	4136.9	6.0	Kk	4168.3	6.6	Kk
	4137.9	6.1	Kk	4170.3	6.6	Kk
	4139.9	6.1	Kk	4170.4	6.0	Kd
	4140.8	6.1	Kk	4172.3	7.1	Kk
	4144.9	6.2	Kk	4172.0	6.1	Pt
	4147.9	6.3	Kk	4176.4	6.9	Kk
	4147.9	6.0	Kd	4182.4	7.0	Kk
	4150.9	6.3	Kk			
194929	RR SAGITTARII—					
	4121.0	7.6	Bl	4137.0	8.2	Bl
	4127.0	7.5	Bl	4144.0	8.6	Bl
195142	RU SAGITTARII—					
	4121.0	7.9	Bl	4137.0	7.1	Bl
	4125.3	7.7	Sm	4144.0	7.6	Bl
	4127.0	7.8	Bl			
195553	NOVA CYGNI—					
	4172.0	12.1	Pt	4182.4	12.2	Pt
	4179.1	12.2	Pt	4196.0	12.3	Pt
195849	Z CYGNI—					
	4172.0	12.4	Pt	4195.1	11.8	Wf
195855	S TELESCOPII—					
	4137.0	13.2	Bl			
200357	S CYGNI—					
	4172.0	13.7	Pt			
200747	R TELESCOPII—					
	4137.0	11.9	Bl	4144.0	11.2	Bl
200822	W CAPRICORNI—					
	4121.0	12.0	Bl			
200938	RS CYGNI—					
	4172.0	7.0	Pt	4173.0	7.4	Ly
201139	RT SAGITTARII—					
	4121.0	9.4	Bl	4137.0	10.2	Bl
	4127.0	9.5	Bl	4144.0	10.8	Bl
201437b	WX CYGNI—					
	4172.0	10.9	Pt			
201647	U CYGNI—					
	4172.0	8.0	Pt			
202240	U MICROSCOPII—					
	4121.0	8.6	Bl	4137.0	8.8	Bl
	4127.0	8.5	Bl	4144.0	8.7	Bl
201946	SZ CYGNI—					
	4172.0	9.6	Pt	4190.0	9.6	Pt
	4173.0	9.8	Pt	4191.0	9.7	Pt
	4179.1	8.8	Pt	4196.0	8.9	Pt
	4181.1	9.2	Pt	4200.0	9.6	Pt
	4182.0	9.1	Pt	4201.0	9.8	Pt
	4188.0	9.7	Pt			
202954	ST CYGNI—					
	4172.0	10.7	Pt	4182.0	11.0	Ie
203226	V VULPECULAE—					
	4172.0	8.5	Pt			
203429	R MICROSCOPII—					
	4137.0	12.6	Bl	4144.0	11.5	Bl
203816	S DELPHINI—					
	4172.0	9.2	Pt			
203847	V CYGNI—					
	4172.0	7.4	Pt			
204215	U CAPRICORNI—					
	4121.0	[11.5	Bl			
204846	RZ CYGNI—					
	4172.0	12.1	Pt	4195.1	12.8	Wf
204954	S INDI—					
	4137.0	13.1	Bl	4144.0	12.9	Bl
205017	X DELPHINI—					
	4172.0	11.3	Pt			
205923	R VULPECULAE—					
	4172.0	9.3	Pt			
210124	V CAPRICORNI—					
	4121.0	8.3	Bl	4137.0	9.1	Bl
	4127.0	8.6	Bl	4144.0	9.6	Bl
210221	X CAPRICORNI—					
	4137.0	11.4	Bl	4144.0	11.5	Bl
210812	R EQUULEI—					
	4172.0	9.5	Pt			
210868	T CEPHEI—					
	4168.0	9.0	B	4175.2	9.4	L
	4172.0	9.3	Pt	4175.9	10.4	Mm
211614	X PEGASI—					
	4172.0	9.8	Pt			
211615	T CAPRICORNI—					
	4121.0	11.3	Bl	4144.0	9.0	Bl
	4137.0	9.2	Bl			
212030	S MICROSCOPII—					
	4135.0	11.5	Sm	4140.3	11.0	Sm
	4137.0	11.4	Bl	4144.0	10.8	Bl
212814	S MICROSCOPII—					
	4137.0	11.8	Bl	4144.0	11.7	Bl
213244	W CYGNI—					
	4147.9	6.7	Kd	4167.4	6.6	Kd
	4152.4	6.6	Kd	4170.4	6.6	Kd
	4164.4	6.6	Kd	4175.4	6.6	Kd
213678	S CEPHEI—					
	4172.0	8.1	Pt			
213753	RU CYGNI—					
	4172.0	7.7	Pt			
213843	SS CYGNI—					
	4127.0	9.0	Kl	4178.0	11.9	Wf
	4133.0	10.5	Kl	4178.0	11.9	B
	4156.2	10.6	Kl	4179.4	11.7	Pt
	4157.2	10.0	Kl	4180.0	11.5	Ly

VARIABLE STAR OBSERVATIONS RECEIVED DURING FEBRUARY, 1925—Continued.

Star	J.D.	Est.Obs.	J.D.	Est.Obs.
213843 SS CYGNI—Continued.				
	4158.1	8.5 L	4180.0	12.0 Ie
	4161.3	8.4 Kl	4181.0	11.9 B
	4162.3	8.5 Kl	4181.1	11.8 Pt
	4164.2	9.0 Wf	4182.0	11.9 Ie
	4166.1	10.3 Br	4182.0	11.7 Pt
	4168.0	11.2 B	4182.1	12.0 Cy
	4170.2	11.3 L	4183.7	11.8 Kl
	4170.7	11.8 Kl	4187.0	11.9 Ie
	4171.2	11.8 Sg	4188.0	11.8 Pt
	4172.0	11.8 Pt	4190.0	11.8 Pt
	4173.0	11.7 Pt	4191.0	11.7 Pt
	4173.0	11.6 Ly	4195.0	11.8 Wf
	4174.1	11.8 Wf	4196.0	11.6 Pt
	4174.7	12.2 L	4198.0	11.7 Pt
	4175.0	12.0 Ie	4200.0	11.7 Pt
	4175.1	11.7 Br	4201.0	11.7 Pt
213937 RV CYGNI—				
	4114.3	8.2 Au	4143.3	8.2 Au
	4114.3	8.5 Au	4143.3	8.0 Au
	4116.2	8.2 Au	4153.8	8.2 Au
	4116.3	8.1 Au	4153.8	8.0 Au
	4117.3	8.0 Au	4160.8	8.0 Au
	4117.3	7.9 Au	4160.8	8.2 Au
	4131.3	8.1 Au	4163.8	8.0 Au
	4131.3	8.0 Au	4163.8	7.8 Au
	4137.3	8.3 Au	4164.7	8.0 Au
	4138.3	7.8 Au	4172.0	7.4 Pt
	4138.3	8.2 Au		
214024 RR PEGASI—				
	4172.0	9.1 Pt	4195.1	9.5 Wf
214247 R GRUIS—				
	4121.0	11.5 Bl	4137.0	12.0 Bl
	4122.3	11.6 Sm	4140.3	12.4 Sm
	4129.1	11.4 Bl	4149.3	12.4 Sm
	4135.3	12.9 Sm		
220133a RY PEGASI—				
	4172.0	12.4 Pt		
220133b RZ PEGASI—				
	4172.0	11.1 Pt		
220714 RS PEGASI—				
	4172.0	11.1 Pt		
221938 T GRUIS—				
	4122.3	10.7 Sm	4140.3	10.3 Sm
	4135.3	10.3 Sm	4149.3	10.3 Sm
221948 S GRUIS—				
	4122.3	8.6 Sm	4140.3	8.1 Sm
	4135.3	8.1 Sm	4149.3	7.8 Sm
222439 S LACERTAE—				
	4172.0	8.4 Pt	4181.0	9.1 B
	4176.0	8.9 Bi		
222867 R INDI—				
	4121.0	11.6 Bl	4137.0	12.7 Bl
	4129.1	11.8 Bl		
223462 T TUCANAE—				
	4122.3	9.3 Sm	4142.3	8.4 Sm
	4136.3	8.7 Sm	4149.4	8.3 Sm
223841 R LACERTAE—				
	4172.0	10.4 Pt	4176.0	10.8 Bi
230110 R PEGASI—				
	4172.1	12.2 Pt	4197.0	11.2 Gd
	4175.0	11.9 Ie	4201.0	10.9 Cd
230759 V CASSIOPEIAE—				
	4171.8	9.9 Mm	4195.0	8.8 B
	4172.1	10.0 Pt		
231425 W PEGASI—				
	4170.2	9.6 Kl	4183.7	9.8 Kl
231508 S PEGASI—				
	4172.1	7.4 Pt		
232848 Z ANDROMEDAE—				
	4152.5	9.6 Mj	4172.1	9.4 Pt
233335 ST ANDROMEDAE—				
	4168.1	9.1 B	4172.1	9.1 Pt
233815 R AQUARII—				
	4172.1	9.0 Pt		
233956 Z CASSIOPEIAE—				
	4176.1	13.7 Bi	4195.1	14.3 Wf
234746 V PHOENICIS—				
	4122.3	9.7 Sm	4142.3	10.0 Sm
	4136.3	9.7 Sm	4149.4	10.4 Sm
235053 RR CASSIOPEIAE—				
	4181.1	13.0 B		
235209 V CETI—				
	4137.0	[13.0 B	4174.8	12.0 L
235265 R TUCANAE—				
	4136.3	[12.9 Sm		
235350 R CASSIOPEIAE—				
	4175.9	10.1 Mm	4197.0	9.6 Ly
	4176.1	9.7 Bi	4197.1	9.6 Lv
	4180.0	9.8 Ly	4199.0	9.6 Ly
	4181.1	10.0 B	4201.0	9.5 Ly
	4195.0	9.7 Ly		
235525 Z PEGASI—				
	4172.1	9.0 Pt		
235939 SV ANDROMEDAE—				
	4172.1	11.8 Pt	4181.0	11.1 B
	4176.1	11.5 Bi	4187.0	10.2 Bi
	4180.0	11.5 Ie		

Observers, 30. Number of observations, 1454. Number of stars, 330.

The following observers have contributed to this report: Messrs. Allen, "Al"; Aurino, "Au"; Baldwin, "Bl"; Berman, "Bi"; Bouton, "B"; Brocchi, "Br"; Chandler, "Cd"; Cilley, "Cy"; Dunham, "Du"; Gaebler, "Gb"; Hama, "H"; Mrs. Holmes, "Ho"; Iedema, "Ie"; Jones, "Jo"; Kanda, "Kd"; K. Kasai, "Kk";

Kohl, "Kl"; Lacchini, "L"; Leavenworth, "Lv"; Mrs. Lytle, "Ly"; Marshall, "Mh"; Millman, "Mm"; Miayajima, "Mj"; Peltier, "Pt"; Schuller, "Sh"; Skaggs, "Sg"; Smith, "Sm"; Waterfield, "Wf"; Whittier, "Wr"; and Miss Young, "Y."

LEON CAMPBELL, Recording Secretary.

GENERAL NOTES

Dr. Joel Hastings Metcalf, Unitarian minister of Portland, Maine, and known for his work in photographic astronomy of the minor planets, died on February 21, aged fifty-nine years. (*Science,* March 6, 1925.)

Professor William H. Pickering, as we learn from a recent letter, has secured a small reflector, with which he is going to determine how fine detail can be detected upon the moon, as compared with that seen with his former 11-inch refractor. He also proposes to study the elliptical disks of Jupiter's satellites.

Astronomical Equipment Stolen from the Haverford College Observatory about ten days before the eclipse; one 10-inch Clark objective, one 8-inch Fitz objective, one finder with 4-inch lens, and numerous eye-pieces. Any information concerning these articles will be gratefully received.

Haverford, Pa. A. H. WILSON, Director.

Observations on Shadow Bands.—Dr. W. J. Humphreys, U. S. Weather Bureau, Washington, D. C., who is a member of the Committee on Eclipses of the American Astronomical Society, has kindly consented to discuss the question of shadow bands observed at the recent total eclipse of the sun.

A request is hereby made that reports of observations be sent to him.

S. A. MITCHELL,
Chairman of the Committee on Eclipses
of the American Astronomical Society.

A Correction.—Professor Frank B. Littell, of the U. S. Naval Observatory, asks us to change the first sentence quoted from his abstract in the March number of POPULAR ASTRONOMY, page 212, beginning with line 23, to read as follows:

"Eclipse observations from airplanes were proposed to the Naval Observatory by Col. John Millis, U. S. A., Ret., in 1918, by Prof. D. P. Todd in 1919, and again by Col. Millis in 1923."

Princeton Observatory Publications.—*Contributions from the Princeton University Observatory,* No. 7, gives the results of study of five eclipsing variable stars: TV, TW and TX Cassiopeiae, T Leonis Minoris, and SS Camelopardalis, by Richard John McDiarmid. The writer says that his work on these stars began in 1912 and continued for nearly three years, with the use of the 23-inch equatorial and polarizing photometer. The whole number of observations discussed in the papers on the five stars is considerably over 50,000.

They are all large stars as compared with the sun, the absolute magnitudes of the brighter components coming out —0.3, +0.3, —3.1, +0.3 and —0.3, re-

spectively, in the order in which the stars are mentioned above, while the sun's absolute magnitude is about 5.0 on the same scale. Their densities are low, all being less than one-fifth that of the sun, while TX Cassiopeiae has less than one-hundredth the density of our star. Its density comes out less than that of any other B-type star except β Lyrae. The distances come out in the thousands of light years, that of TX Cassiopeiae being approximately 10,800 light years.

An Extraordinary Measure of Time Indeed.—At the celebration of the 80th anniversary of the birth of Elihu Root as reported in "Time" Feb. 23, 1925: "Then Mr. Root arose: It was 57 years ago that I joined the "Union League Club." Of the men who joined in that year, only three are now alive: George F. Baker, Chauncey M. Depew and myself . . . . Mr. Baker travels on golden clouds and Mr. Depew has given up counting his years by ordinary measures of time, using light years instead."

The Southern Cross Observatory at Miami, Florida, closed its third and most successful season on March 20 with a dinner given by S. Lynn Rhorer, the founder and active director, to his assistants during the winter. The Observatory lays claim to being the only outdoor institution of its kind in the country. It has been in existence for three years, commencing in 1922 with a five-inch Clark refractor which Mr. Rhorer set up among the palms in Royal Palm Park in the center of the city, and has been enlarged each year with another glass of the same kind. Mr. Rhorer intends to add one instrument each year until 1928, which will give the Observatory an equipment of seven telescopes. He also plans for next year a visual spectroscope of the type recently manufactured for popular use.

During the season of three months, the Observatory has been open every evening from 7:00 to 10:30 P. M. and during the last month, the interest in Saturn was such that the time was frequently extended. In addition, two mornings weekly, from 5:00 A. M. to sunrise, were devoted to observation. It is conservatively estimated that ten thousand people used the instruments during these times, and during the height of the season Mr. Rhorer and his assistants found it difficult to accommodate the large numbers who showed interest in the science. The Miami papers supported the project with a daily paragraph in description of some interesting object and also printed an extended discussion of some phase of astronomy in each Sunday edition.

The seeing conditions at Miami are both favorable and unique. Only six evenings were lost through weather conditions in three months. A large field of the sky unknown to northern observers is visible at Miami, and to many of the northern tourists, Canopus and the Southern Cross were of great interest. The latter, with Alpha and Beta Centauri, is just above the horizon at Miami. It may surprise the readers of POPULAR ASTRONOMY to learn that every first magnitude star is visible at Miami and the prevailing weather conditions allow good seeing to a point practically on the horizon.

The culmination of the season was the lecture by Dr. Harlow Shapley on "How Worlds are Made," to an audience of about 800 people. The auditorium was filled in spite of lack of publicity through Dr. Shapley being delayed by train connections. The scholarly and at the same time popular and witty address was received with such appreciation that the Observatory has earned itself a prominent place in the city, and will be accorded a location in the new Bayfront Park

for next season, where it will again fill its purpose of offering pleasure and knowledge to the man in the street.

Mr. Rhorer makes a special request, that any of the readers of POPULAR ASTRONOMY who may intend to visit Florida next year prseent themselves at the Observatory after January 1 and give their assistance in the popular evenings, and also offer any other aid in lectures or otherwise as may be possible.

JAMES J. MARSHALL.

University Extension Course in Astronomy.—The following courses given this year at the Normal Art School, Exeter and Newbury Streets, Boston, Thursdays at 7:30 P. M., will be interesting to some of our readers. The charge for this course was $2.

"This is a descriptive, non-technical course that will be of interest to the general public. The content and illustrative material have been planned by Leon Campbell, Astronomer, Harvard College Observatory, in consultation with the staff of the Division of University Extension."

Jan. 15—*Coming Eclipses of the Sun and Moon*, Professor Edward S. King, Harvard College Observatory.

Jan. 22—*Bright Stars and Constellations*, Horace Taylor, Science Instructor, Brown and Nichols School.

Jan. 29—*Sun and Moon*, Mrs. Eleanor Ingelfinger, Lecturer, Swampscott.

Feb. 5—*Modern Astronomical Observatories*, Leon Campbell, Astronomer, Harvard College Observatory.

Feb. 12—*Our Planetary System*, Professor Lewis A. Brigham, Boston University.

Feb. 19—*Comets and Meteors*, Professor Harlan T. Stetson, Harvard University.

Feb. 26—*The Origin of the Planets*, Professor Alfred C. Lane, Tufts College.

Mar. 5—*The Milky Way*, Professor Solon I. Bailey, Harvard College Observatory.

Mar. 12—*The Variability of Stars*, Leon Campbell, Astronomer, Harvard College Observatory.

Mar. 19—*Star Systems Beyond the Milky Way*, Professor Harlow Shapley, Director of Harvard College Observatory.

Variable Star Results from the B. A. A.—The appendix to the *Memoirs of the British Astronomical Association*, volumes XXII and XXV, gives the light curves of 35 long-period variable stars, drawn from the observations of the members of the Variable Star Section during the decennium 1910-1919. The curves are printed on an ample scale on long sheets of paper, folded and filed loose in a neat box, which makes them very accessible and convenient for use. A 20-page pamphlet accompanies the plates, giving explanations and discussion of the curves with lists of the determined maxima and minima. Director C. L. Brook and Col. E. E. Marckwick are to be congratulated on the valuable results obtained and the convenient form of publication.

The Praesepe Cluster.—In the *Bulletin of the Astronomical Institutes of the Netherlands* Mr. W. J. Klein Wassink gives results of measures of a number of photographs, taken at different observatories and repeated after considerable intervals of years, for the purpose of determining the proper motions of the stars in the Praesepe Cluster, and thus ascertaining which stars really belong to the cluster.

From five pairs of plates taken, 2 at Pulkovo, 2 at Greenwich, and 6 at the

Radcliffe Observatory, with intervals of 29, 29, 15, 15 and 14 years respectively, Mr. Wassink finds 173 stars between magnitudes 6.3 and 13.8 which pretty certainly belong to the cluster within an area of 2.84 square degrees. Within the same area he finds 358 stars between magnitudes 7.0 and 14.0 which are not identified with the cluster by their proper motions. The distribution of the non-cluster stars with regard to number and magnitude agrees closely with the theoretical distribution, as shown by the following table:

COMPARISON OF OBSERVED AND COMPUTED NUMBER OF NON-CLUSTER STARS PER 2.84 SQUARE DEGREES.

Photographic Magnitude	Observed Number	Computed Number	Photographic Magnitude	Observed Number	Computed Number
7.0 - 8.0	1	1	11.0 - 12.0	55	52
8.0 - 9.0	2	3	12.0 - 13.0	110	99
9.0 - 10.0	3	9	13.0 - 14.0	165	196
10.0 - 11.0	23	22			

The distribution of the stars belonging to the cluster is quite different, as will appear from the next table, which was prepared by the writer of this review.

DISTRIBUTION OF CLUSTER STARS WITH REFERENCE TO NUMBER AND MAGNITUDE.

Photographic Magnitude	Observed Number	Photographic Magnitude	Observed Number
6.0 - 7.0	4	10.0 - 11.0	23
7.0 - 8.0	13	11.0 - 12.0	31
8.0 - 9.0	19	12.0 - 13.0	31
9.0 - 10.0	34	13.0 - 14.0	18

The proper motions measured range from —0″.010 to —0″.050 in right ascension and +0″.002 to —0″.042 in declination, the averages for the 173 stars being —0″.0334 and —0″.0126 in α and δ respectively. This gives a mean annual motion for the cluster of 0″.0357 in the direction P. A. 259°.3.

The Time Service in New Zealand.— The time-signals sent out from the Observatory mean-time clock and the wireless time-signals as described in the last report continue to be distributed and appreciated by those concerned. With the single-valve wireless receiving-outfit, time-signals have been heard from Pearl Harbour (NPM), Hawaii, at 11:30 A. M.; from Bordeaux (LY), France, at 7:30 A. M.; and from Annapolis (NSS), Washington, at 8:30 P. M. The Annapolis signals were a special set sent to Alaska, and ceased in October, 1923. The regular signals from Annapolis at 2:30 P. M. have never been heard at the Observatory.

An improved wireless receiving-set has been installed at the Observatory consisting of one high-frequency stage of amplification, one detector-valve, and two stages of low-frequency amplification. With this outfit the time-signals are heard more strongly, and the time signals from Java (PKX) at 12:30 P. M., and Kavite (NPO), Philippines, have been heard. On an average about 50 percent of these signals are heard sufficiently clearly to be made use of.

The time-signal from Nauen (POZ), Germany, at 11:30 P. M. was heard on the 20th February.

In addition to the ordinary time-signals sent from Pearl Harbour, Hawaii, at 11:30 A. M., the Naval Observatory, Washington, has arranged for the transmission of a scientific time-signal, immediately following the usual one. This has been recorded at the Observatory whenever it was heard, and was similarly recorded by the other observatories round the Pacific. (From the Hector Observatory, Wellington, New Zealand, *Bulletin* No. 55.)

SHORT ECLIPSE NOTES.

(Continued from p. 220.)

At New Haven, Connecticut.

During the eclipse of the sun on January 24, as seen at New Haven, the shadow bands were very plainly visible on the snow for several minutes preceding and following the period of totality. I examined them carefully and could see no appearance of bands, i. e., parallel lines of shadow. The closest comparison I could think of was that of shadows which might be produced if the sun were shining through rain which was falling "in sheets." There was no approach to regularity. The direction of the motion was from the sun toward me. I could discern no motion perpendicular to this line, except possibly a slight flickering, or wavering, motion.

In our laboratory the other afternoon the appearance of the shadow bands was duplicated to a very striking degree. The sun was shining through an open window which had a steam radiator beneath it. The convection currents above the radiator were rising vertically, undisturbed by any horizontal currents. Where the sunshine fell on the floor, about fifteen feet from the wall, the "shadow bands," in size, direction and rate of motion, appeared just as they did at the time of the eclipse. Repeating the experiment on another day, when there was a draft through the window, there was a sidewise motion imposed on the other one.

May there not be a suggestion here of an explanation for the shadow bands? Upward convection currents of air at a greater distance from the illuminated surface would produce this same appearance if the luminous area were not too large. During the minute or two just before and after totality, the luminous surface of the sun is small enough so that the effect is manifest. If no horizontal currents exist at the level where the upward currents are, the motion of the bands would be as I saw it. A horizontal current combined with the convection currents would give a sidewise motion to the bands.

If the shadow bands are due to convection currents in our atmosphere, they should be visible whenever a star or planet will illuminate a surface brightly enough for the effects to be seen. Sirius will not do it. Possibly Venus near its maximum elongation will. A white surface shielded from all other illumination will be necessary, as the effects will be faint at the best and, if present, are ordinarily entirely masked by other illumination. The bands will probably move in the opposite direction, i. e., toward the source of light, since the convection currents will be downward at night. It will be an interesting experiment to perform next November, when Venus is favorably placed.

Middlebury College. Ernest C. Bryant.

At East Rock in New Haven, Connecticut.

In observing the total eclipse of the sun on January 24, 1925, from the summit of East Rock in New Haven, Connecticut, our party witnessed some odd variations in the shadow bands which I have not seen mentioned in the descriptions of the bands observed at other eclipses. A white cotton sheet was spread over the top of the low wall near the summit house on the western edge of the summit. It is precipitous below this point. The sun was in clear sky and the temperature near 0° F.

I first noticed uncertain waverings on the sheet at seven minutes before totality. The faint irregular, small, grayish ripples seemed little more than the irregularities in sunlight which falls on the ground after passing through the ascending air columns from a chimney. In a few moments they seemed more definite and yet were too elusive to allow me to catch their width with two meter sticks which I had at hand for the purpose. I placed one stick on the sheet to indicate their direction. At that time the shadow lines did not appear to be more than a quarter of an inch wide and were perhaps an inch apart. They extended in a direction 34° west of north (magnetic) as determined after totality from the position of the undisturbed meter stick using a Stoppani precision compass. No change in the direction of the extent of the bands was noticed at any time.

When first seen the bands were moving in a direction apparently perpendicular to their length, traveling away from me in a direction somewhat south of west.

At 6½ minutes before totality the bands completely vanished for about 15 seconds. I also observed them to vanish for another short interval later. At 4½ minutes before totality the bands had grown wider, perhaps half an inch wide and were separated by perhaps two inches. It was impossible to make anything other than a rough estimate of their widths.

At one time the bands faded for a moment and reappeared in the same direction but moving toward me, somewhat north of E. This reversal of motion lasted for 15 seconds or more and was clearly noted by several of our party who stood beside me.

At another time the bands seemed to stop in their south of west motion and to move lengthwise in an east of south direction. This seemed incredible at the time but the impression was certainly a positive one.

No color was seen on the bands or between them, neither did they appear to come in groups at any time.

Two of my party who watched the bands after totality reported that they were still parallel to the meter stick and that they disappeared for 3 or 4 brief intervals before they were last seen at $5^m\ 10^s$ after totality. The error of my watch was determined by comparison with the Yale Observatory clock shortly after the eclipse and has been allowed for in the times given above.

Department of Astronomy, Boston University. LEWIS A. BRIGHAM.

AT WESTON, MASSACHUSETTS.

The eclipse of January 24, 1925, was observed with much interest by our students here at Fairview, Weston, Mass., about 42 miles north of the path of totality. Weather conditions were favorable except for some clouds about the sun, especially at the maximum, but these did not interfere very much with the seeing. Smoked glasses, several small telescopes and two surveyors' transits, by means of which the sun's image was projected upon a screen, were employed. Thermometer and barometer readings were taken at intervals from 8:00 A. M. until about 10:00 A. M. E. S. T. The temperature at the first contact about 8:05 was 3.3 F and it dropped 1.0 degree, rising again after the maximum. The barometer fell during the eclipse but, as it fell quite steadily throughout the whole day, it is unlikely that any special significance can be attached to the drop. Though about 99 per cent of the sun's disk was covered, the darkness was less than was anticipated, the snow on the ground helping to diffuse the light. It was greatest towards the northwest and resembled that preceding a storm. The crescent was not fine enough to show Baily's Beads and on account of clouds only Venus was

seen. At the maximum a replica grating held before the eye clearly showed the curved lines of the solar spectrum. Chickens stood idly in their quarters but made no attempt to go to roost, while pigeons were observed to return home. Several photographs of the partially eclipsed sun were made. A beam of sunlight was brought into a darkened class room by means of a porte-lumiere with a total reflecting prism. A single lens, 2½ inches in diameter and of about 12 ft. focal length, was placed in the path of the beam with an aperture of ¼ inch, and a graflex camera with the lens system removed was mounted at its focus. Films were used, several trial exposures being made to determine th proper time of exposure.

H. M. Brock, S. J.

At North Scituate, Rhode Island.

The total eclipse of the sun was observed at the North Scituate, R. I., Observatory under the most favorable conditions. Sky nearly clear most of the time, with a west to northwest wind, and a temperature of —2° at sunrise. At the time of first contact, which was taken in sidereal time (by Kulberg Sidereal Chronometer 1178), light fleecy clouds covered the sun, but these did not interfere in any way. The low altitude of the sun, and the very bad seeing rendered the time uncertain by several seconds. The time noted by Kullberg 1178 and reduced to mean time gives $8^h\,03^m\,58^s$ for the first contact. The first photograph was taken of the partial phase fifteen minutes after first contact. When the sun's disc was reduced to a thin crescent I went up to the dome where the twelve-prism Browning Solar Spectrograph was attached to the 8½-inch equatorial. I placed the slit of the spectroscope tangent to the sun's north limb and brought the Hβ and Hγ lines into the field of view and then waited for totality. At the instant of totality (and only for about three seconds) every line in the field of view became bright. As the North Scituate Observatory was just inside the north edge of the shadow, totality lasted only five seconds. About a minute after totality the shadow bands were seen by all the observers here. Venus, Jupiter, Mercury, Vega and Altair, all became visible to the naked eye. During the eclipse not a spot or facula was visible on the sun's disc. Two small spots disappeared at sun's western limb on January 23. The corona to my eye was a typical minimum spot one. It resembled the coronas of the eclipses of July 29, 1878, and May 28, 1900. The photographs were taken by members of the Providence Journal staff. Mr. Boss and Mr. Mowry observed the eclipse visually and photographically at New Haven, Conn., and will report later. The eclipse of January 24, 1925, was the fourth total eclipse of the sun that I have had the good fortune to observe.

Frank E. Seagrave.

At Woodstock, Maryland.

I am sending you the results of our observations of the eclipse of January 24, which had a magnitude of 95 per cent here. The differences between the observed and computed times seems much too large to be explained fully by any errors of observation.

	First Contact	Last Contact	Duration
Predicted	$12^h\ 55^m\ 29^s.9$	$15^h\ 22^m\ 38^s.6$	$2^h\ 27^m\ 8^s.7$
Observed	12 55 45	15 22 23.2	2 26 38.2
Difference Pred. — Obs.	—15^s	15^s.4	30^s.5

Woodstock College Observatory. Edward C. Phillips, S. J.

AT DENVER, COLORADO.

The following observations of last contact for the eclipse of January 24, 1925, were made at the Chamberlin Observatory of the University of Denver. The sky was perfectly clear, but the sun's limb was much disturbed, on account of its low altitude. Instantaneous photographs taken by Mr. J. D. Elder with a 5-inch lens, of about 24 ft. focal length, attached to the tube of the 20-inch equatorial, showed very plainly the undulations on the sun's limb and the distortion of its disc due to refraction. The times given below are all Mountain Standard.

The Misses Julia Allam, Hope Getty, Dorothy Wilson, and Ruth Wilson observed with engineer's transit-instruments and stop watches. The mean of their times is $7^h\ 46^m\ 53^s.0$.

The other observations follow:

Aperture	Mag. Power	M. S. T.	Observer
2.75	33	$7^h\ 46^m\ 55^s.6$	Alice Boyd
3.4	80	7 47 2.4	Theodore R. Rhea
5.0	55	7 46 47.3	David H. White
6.0	60	7 46 59.9	Janet Milligan
20.0	175	7 46 59.5	Herbert A. Howe

The first three of these times were noted with stop watches; the last two chronographically.

HERBERT A. HOWE.

New Comets *a* and *b* 1925. — As we were closing up the last forms of this issue of POPULAR ASTRONOMY, the discoveries of two new comets were announced by cablegram from Copenhagen to Harvard College Observatory, the one by Schain at Hamburg, Germany, the other by Reid of Cape Town, Africa.

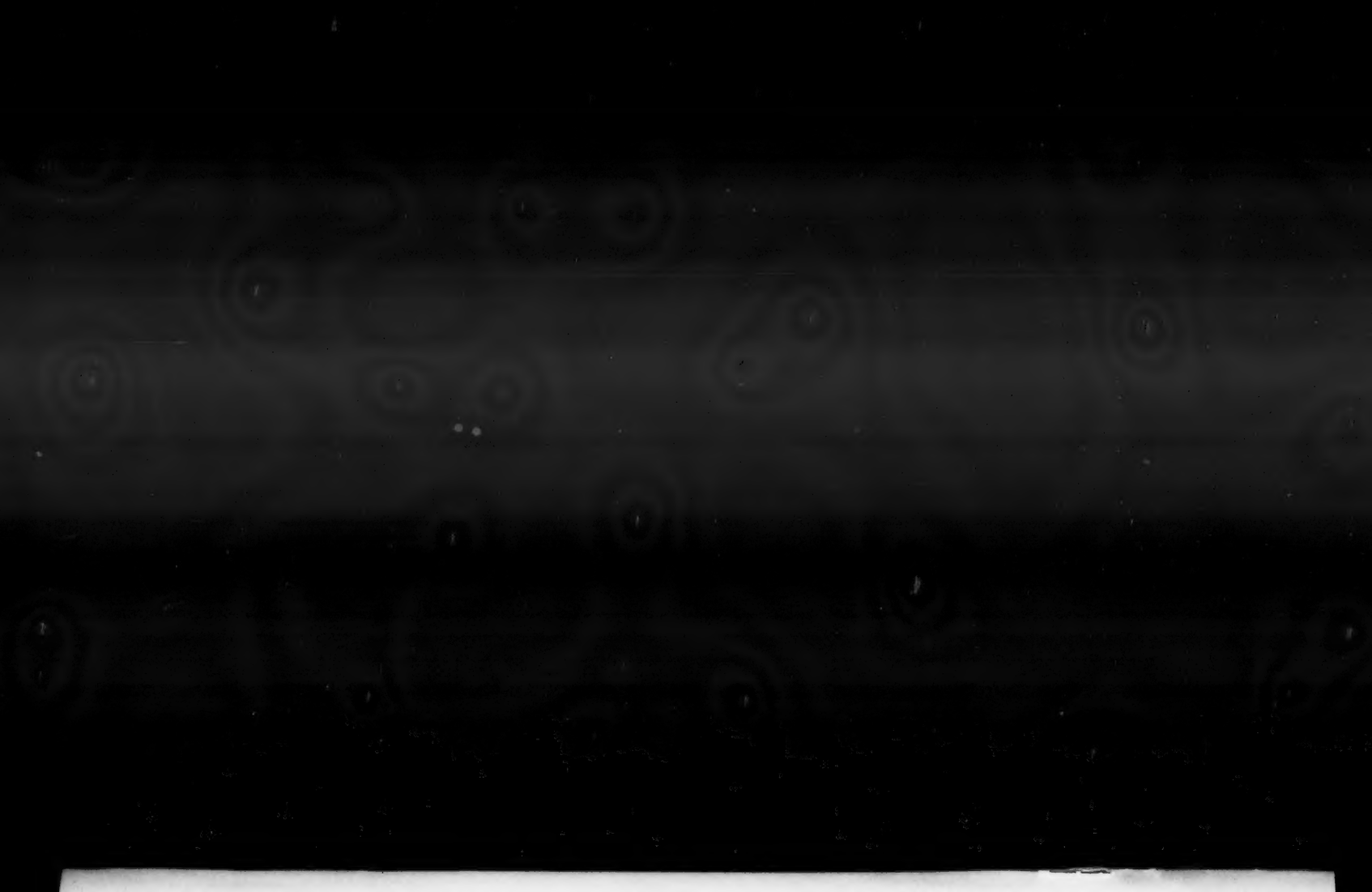
Schain's comet was near β Virginis on March 23 and is moving westward nearly parallel to the ecliptic. It will be in the constellation of Leo during April. It is at present a faint object but readily seen with a 5-inch telescope. In the 16-inch telescope it appears round, about 1′ in diameter with a slight central condensation, and a nucleus of about magnitude 13.

Reid's comet is easily seen with a 3-inch telescope. It was about 10° south of Spica (α Virginis) on March 24 and is moving slowly southwest. It will be near the star γ Hydrae in the first half of April. In the 16-inch telescope on March 27 it appeared of about 3′ diameter, with a strong central condensation and a very faint tail, spreading slightly and extending 5′ or 6′ toward the north following direction.

The following positions of the two comets have come to hand:

OBSERVATIONS OF COMET *a* 1925 (SCHAIN).

Gr. C. T.	α h m s	δ ° ′ ″	Observer	Place
Mar. 23.9470	11 47 48.9	+ 1 43 49	Schorr	Hamburg
26.1611	11 43 48.8	+ 1 54 55	Bower	Washington

OBSERVATION OF COMET *b* 1925 (REID).

Gr. C. T.	α h m s	δ ° ′ ″	Observer	Place
Mar. 24.8979	13 29 47.0	—20 16 00	Reid?	Cape Town?